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BUREAU OF ANIMAL INDUSTRY.—BULLETIN 155.

A. D. MELVIN, CHIEF OF BUREAU.

THE INFLUENCE OF THE STAGE OF LACTATION ON THE COMPOSITION AND PROPERTIES OF MILK.

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BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., June 29, 1912.

Sir: I have the honor to transmit, and to recommend for publication in the bulletin series of this bureau, the accompanying manuscript entitled "The Influence of the Stage of Lactation on the Composition and Properties of Milk," by Prof. C. H. Eckles, of the Missouri Agricultural Experiment Station, and Mr. Roscoe H. Shaw, of the Dairy Division of this bureau. The experimental work herein described forms a part of the investigations concerning milk secretion which are being conducted at the Missouri station in cooperation with this bureau.

There is a considerable amount of data available bearing upon the lactation period of cows and the effects on the composition of the milk, but as a rule such investigations have been confined to a single constituent of the milk, usually the fat. No record could be found of any investigation with controlled animals where all or even a majority of the milk constituents have been studied during a complete lactation period. Accordingly it was deemed advisable to undertake the present work so as to cover this point satisfactorily. The cooperative work mentioned has been in progress for about six years. Investigations regarding the influence of other factors concerning milk secretion are also under way and will be reported later.

The authors desire to acknowledge their indebtedness to Messrs. A. E. Perkins, J. O. Halverson, and J. C. Payne, formerly of the Dairy Division, for assistance rendered in compiling the data in this bulletin.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE INFLUENCE OF THE STAGE OF LACTATION ON THE COMPOSITION AND PROPERTIES OF MILK.

INTRODUCTION.

It is a well-known fact that although the same constituents are always present in milk, the relative amounts of each are subject to constant variation. These variations in composition are known to be influenced by a number of causes, among which are (1) the breed of the animal, (2) the individuality, (3) to some extent the feed, (4) the interval between milkings, (5) the various stages in the period of lactation, (6) more or less by the health of the animal and by temperature and weather conditions. It is also known that the fore milk and the milk last drawn differ in composition, and that some variations occur between morning and evening milkings. A large number of observations are recorded regarding these variations and their causes, mostly, however, in connection with the fat alone. The data regarding certain of these factors are consistent and conclusive, but concerning others they are conflicting and insufficient to justify general conclusions. The main criticisms to be made regarding the large amount of data that has been published along these lines is that in most cases only the per cent of fat was taken into account and that the animals supplying the samples were not properly selected and controlled.

In 1906 an agreement was entered into between the Missouri Experiment Station and the Dairy Division, Bureau of Animal Industry, United States Department of Agriculture, for a series of investigations, the main object of which was to be a further study of the factors influencing the composition and properties of normal milk. In beginning such a line of investigation it was decided that it would be necessary to repeat much of the work that had been done in the past, but under more carefully controlled conditions, in order that results might be more definite. There are a number of questions that have to be considered in planning all such investigations regarding the selection of suitable animals to furnish the samples. Among the questions that always arise in this connection are the three following: The effect of the stage of lactation, the influence of the breed, and the individual variations. The logical plan in beginning such a series of investigations as was contemplated seemed to be first to supply further data on the effect of the three factors mentioned. The data at the same time would serve as a basis for the planning of future work regarding the influence of other factors.

Since the various stages in the period of lactation represent a factor always to be taken into account and one known to have an important bearing on the composition of milk, plans were made to begin these investigations with this as the first main objective point. The plans were so arranged that the same data would also add to our knowledge regarding the influence of the other two factors, i. e., the breed and individuality of the animal.

In this publication the influence of the stage of lactation alone is considered. The data regarding the influence of breed and individuality of the animal are to be published in the near future.

PREVIOUS INVESTIGATIONS.

There is a mass of data available which has a connection either near or remote with the influence of the stage of lactation on the chemical composition of milk. The advent of the Babcock test in 1890, which offered a rapid and simple method for the determination of fat, lent a stimulus to such investigations. As a whole the investigations along this line which have been published have been limited to a single constituent of milk, usually the fat. In but few cases has any attempt been made to eliminate the influence of the feed of the animals, and there is no record of any investigation on controlled animals where all or even a majority of the milk constituents have been studied during an entire lactation period.

No purpose would be served by giving a complete list of the works published on this subject. From a large number of references the following have been selected as representing the more important investigations having to do with the influence of the stage of the lactation period on the chemical composition of milk:

Schrodt and Henzold [1] in 1888–1891 conducted a series of investigations on the composition of butterfat and its variation as influenced by the period of lactation, feed, etc. The first investigation was conducted with mixed milk from a herd of 10 cows of Angler, Brietenburg, and Shorthorn-Dithmarschen breeds and with milk from an individual Angler cow. The second investigation was conducted with the mixed milk from a herd of 220 cows of Angler and Ayrshire breeds. The cows were not kept on a uniform ration. In both investigations they were stall-fed in the winter and put out to pasture during the summer months. Samples were taken from the one Angler cow every day for the first 16 days after calving, then every

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[1] Schrodt, M., and Henzold, O. Untersuchungen von Butterfett. Die Landwirtschaftlichen Versuchs-Stationen. vol. 38, p. 349–371. Berlin, 1891. Vol. 40, p. 299–309. Berlin, 1892.

3 or 4 days till the end of the lactation period. The samples of herd milk in both investigations were taken twice weekly. The milk was skimmed, churned sour, the butter melted, and the clear fat filtered off. Determinations were made on the samples from the individual cow of volatile acids, iodin number, and the refractive index. On the mixed milk the same determinations were made and in addition the determination of the insoluble acids. In the case of the mixed milk the stage of the lactation period was found by averaging the lengths of the periods that the individual cows had been in lactation. In all of the investigations the course of the variation of the different constituents was practically the same through the lactation period. The following conclusions were reached:

In the first milkings the percentage of volatile acids in the fat is very low, but it rises rapidly in the first few days to a maximum value. Then it remains stationary for about 2 months, after which it declines steadily until the close of the lactation period.

The content of olein as shown by the iodin number constantly decreases during the lactation period.

In the latter part of the lactation period the percentage of insoluble acids is higher than in the first part.

As a rule the decrease in the volatile acids is accompanied by an increase in the refractive index.

Apparently the composition of the butterfat bears a close relation to the stage of lactation, but none to changes from stall feeding to pasture feeding.

Klein and Kirsten[1] in 1901 and 1902 conducted an investigation on individual samples from five cows to find the effect of age of the cows and of the stage of lactation on the composition of the butterfat. The cows selected were of different ages. Three were old cows, aged respectively 13, 9, and 8 years. Two were 3-year-old cows. All of the cows were given the same feed, but the feed was not uniform throughout the lactation period. Samples were taken at intervals of approximately one month. The determinations included the Reichert-Meissl number, Koettstorfer number, Hehner number, Hubl number, and refractive index.[2] Curves were plotted from the results and the following variations due to the period of lactation shown:

The Reichert-Meissl number showed a gradual decrease throughout the lactation period.

The Koettstorfer number followed approximately the same variations as the Reichert-Meissl number. In two cows it rose near the end of the period.

The curve for the Hehner number rose during the entire period. It showed variations which were in the opposite direction to those of the Reichert-Meissl number.

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[1] Klein, J., and Kirsten, Arthur. Untersuchung über die chemische Zusammensetzung des Milchfettes einzelner Kühe von verschiedenem Alter im Laufe einer Laktation. Milch Zeitung, vol. 31, no. 37, p. 577-578, Sept. 13; no. 38, p. 594-596, Sept. 20; no. 39, p. 611-613, Sept. 27. Leipsic, 1902.

[2] For the methods used in these determinations see footnote on page 22.

In general the Hubl number showed a rise with the period of lactation, but in 2 cows there was a decline near the end of the period. The authors ascribe this variation to a change in the feeding.

The refractive index showed the same variations as the Hubl number.

There were many minor variations which were thought by the authors to be due to difference in feeding.

Penny,[1] of the Delaware Agricultural Experiment Station, secured some data on the effect of the stage of lactation on the composition of milk from testing the large herd of a Delaware dairyman. Three series of tests were made, each series covering 5 consecutive days, the series being located along the course of lactation as follows: The first, 2¼ months after calving; the second, 6¼ months; and the third, 10¼ months.

From these Prof. Penny concludes that the quantity of milk decreases more or less gradually, and the quality increases in nearly the same ratio, as the lactation period advances.

Hinchcliff[2] at Leipsic in 1901–2 conducted a careful investigation, which included among other factors the influence of the stage of lactation on the chemical composition of milk. His laboratory work is so thorough that it is to be regretted that the number of animals was so limited and his data concerning them so uncertain.

He studied the milk from 3 cows, one of these from the third week of the lactation period to the end and another from the seventh month of the lactation period to the end. Data concerning the condition of the third were lacking, but he states that she was apparently fresh when the study was commenced. The study of the third cow was also carried on to the end of the lactation period. He took samples from each milking for 5 or 6 successive days, which length of time he calls a period. These periods, with but few intervals, succeed each other during the whole lactation period. Analyses were made of each sample and averages calculated to represent the period. No attempt was made to feed the cows on a uniform ration, but a record was kept of the feed given them.

He found that the greatest variations were in the fat, followed by sugar, protein, and ash in the order mentioned. An increase or decrease in the fat content of the milk was usually accompanied by a similar change in the fat content of the milk solids, but by an opposite change in the percentage of protein and sugar in the milk solids. The ash content of the solids not fat was practically constant. Variations in the content of the solids not fat read inversely to the variations in the protein content. In general the percentages of fat, protein, and ash increased with the progress of lactation.

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[1] Penny, Charles Lyndall. Herd-testing. Delaware Agricultural Experiment Station, Tenth Annual Report, p. 159–197. Wilmington, 1898.

[2] Hinchcliff, Joseph Henry. Die täglichen Schwankungen im Gehalte der Kuhmilch an den einzelnen Bestandteilen im Verlaufe der Laktation. Mitteilungen des Landwirtschaftlichen Institutes der Universität Leipzig, No. 5, pp. 1–112. Berlin, 1904.

Swaving[1] in 1889–90 investigated the butterfat from cows in various provinces in Holland with a view of establishing the limits of the volatile fatty acids in butter in order to distinguish pure butter from butter substitutes. He took samples from the different provinces at regular intervals for a considerable period of time, and concludes that at the beginning of the lactation period the percentage of volatile fatty acids increases, but that it decreases as the period progresses.

Schellenberger,[2] in the University of Leipsic, made a study of the size of fat globules with reference to the different breeds and periods of lactation. His published tables gave figures in which he shows that the Jersey cow has the largest-sized globules and the Angler cow the smallest. He also shows that as the lactation period progresses the size of the globules decreases.

Hills,[3] of the Vermont station, studied the results of over 100 lactation periods of cows of many breeds, with diversified feed and in three geographical localities, namely, New York, Minnesota, and Vermont. His conclusions are given in a summary, in which he states:

> The average spring cow rapidly betters the quality of her milk, beginning about 5 months after calving; the summer cow starts in as early as the third month; while the fall cow maintains a fairly even quality throughout her lactation period, seldom improving it more than 5 per cent in fat content. The percentage of solids not fat also is more uniform month by month in the milk of the fall cow. The percentage of solids not fat in the milk of spring cows seems to lessen somewhat in the summer time.

The greatest monthly variation in the quality of the milk of 115 cows was 3.11 per cent fat; the least 0.33 per cent fat. The average variation was 1.26 per cent fat; the average monthly variation of spring cows was 1.62 per cent fat; of fall cows, 1.08 per cent fat; of summer cows, 1.25 per cent fat. Two-thirds of the Vermont and Minnesota herds gave thinnest milk during the first 2 months and two-thirds of the New York herds during the first 4 months. Ninety per cent of the Vermont and Minnesota cows gave their richest milk after the seventh month. Sixty per cent of the New York cows gave their richest milk before the eighth month.

Speir,[4] at Newton Farm, Glasgow, reviewed the records of about 400 cows that were included in the herds of members of a more or less local testing association, with a view of studying the changes in the percentage of fat as the lactation period advanced. His scheme was substantially as follows: The cows were divided into groups, each group representing the cows which had calved within a certain period, usually 2 weeks. The shortest fraction of the lactation period was 1 week and the longest period was 14 weeks. His figures show that the fat content was highest during the first week and lowest during the fourth week, after which a gradual increase was observed.

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[1] Swaving, A. J. Sättigungszahlen für die flüchtigen Fettsäuren der niederländischen Buttersorten. Die Landwirtschaftlichen Versuchs-Stationen, vol. 39, pp. 127-141. Berlin, 1891.

[2] Schellenberger, O. Ueber die Grosze und die Zahl der Fettkügelchen in der Milch von Kühen verschiedener Rassen. Milch Zeitung, vol. 22, No. 50, pp. 817-819. Bremen, Dec. 16, 1893.

[3] Hills, Joseph Lawrence. Variations in milk. Vermont Agricultural Experiment Station, Ninth Annual Report (1895), pp. 158-186. Montpelier, 1896. See p. 158.

[4] Speir, John. Milk records. Transactions of the Highland and Agricultural Society of Scotland, ser. 5, vol. 17, pp. 182-212. Edinburgh, 1905.

Dean[1] tested 6 cows for 273 days at the Ontario experiment station. He divided this time into 3 periods of 91 days each, and averaged the percentage of fat in each period. He states that he found no such increase in percentage of butterfat in milk as is generally accredited to the influence of the period of lactation, there being an increase of but 0.17 per cent in the second period and 0.46 per cent in the third over that of the first period.

Cooke,[2] after studying the complete records of the Vermont station, which covered a period of several years, gives these conclusions regarding the influence of the stage of lactation on the composition of milk:

> All cows shrink in quantity of milk as they get farther from calving. If they are farrow, this shrinkage in quantity is accompanied by almost no change in quality, even until they go dry, provided they are still farrow. If they are in calf, the milk increases in quality as it decreases in quantity; this increase is slight—but one-twentieth during the first 6 months after calving—but becomes quite pronounced just before the cow goes dry.
>
> Cows that calve in the spring give on the average more milk during the first 3 months after calving than those that calve in the fall. For the seventh, eighth, and ninth months this is reversed. Fall cows show smaller variations in the quality of the milk than cows that calve in the spring. The milk of a cow for the first few days or weeks after calving is very variable in quality. On the average, it is thinnest just after calving, becomes slightly richer during the next 2 weeks, and then holds almost uniform in quality for the next 4 or 5 months.
>
> Just after calving the milk is poorer in fat and in solids not fat than just before the cow went dry. The average drop in fat is 1.13 per cent, the greatest change being 2.35 per cent and the least 0.49 per cent. The average change in solids not fat is a fall of 0.47 per cent, with variations from a decrease of 1.94 per cent to an increase of 0.42 per cent.

Pingree,[3] of Pennsylvania, has published some literature on this subject. The extent of the data on which his deductions are based may be indicated by using the author's own language:

> In cooperation with the Dairy Breeders' Association and in connection with the advanced registration of dairy cows, the station has made the official examination of about 1,500 milk samples representing the product of 128 cows from 11 herds.

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[1] Dean, Henry Hoshel. Record of our dairy herd. Ontario Agricultural College and Experimental Farm, Seventeenth Annual Report (1891), pp. 173-175. Toronto, 1892.

[2] Cooke, Wells Woodbridge. Variations in quantity and quality of milk. Vermont Agricultural Experiment Station, Sixth Annual Report (1892), pp. 90-119. Burlington, 1893. See p. 90.

[3] Pingree, M. H. Report of the composition of milk from herds competing for advanced registration. Pennsylvania Agricultural Experiment Station, Annual Report (1905-1906), part 2, pp. 54-93. Harrisburg, 1906. See p. 54.

The author's conclusions in summary may also be given in his own words:

> The percentages of butterfat showed, on the average, a tendency to increase throughout the entire lactation period, but the increase was most marked during the first 5 months and the last month. The percentage of solids not fat decreased somewhat as the lactation period advanced.

Linfield[1] prepared 2 tables from Utah data which are calculated to indicate in some measure the character of changes in the composition of milk that are due to the advance of the period of lactation. Twelve cows were used in this investigation. They were nearly all ordinary grade animals. The lactation season in each case was divided into periods of 4 weeks each, beginning 3 weeks after calving. The author's summary is substantially as follows:

> The decrease in milk and fat yield is fairly constant and averages about 9 per cent decrease each period of 4 weeks.
>
> The yield of butter fat does not decrease as rapidly as the milk, due to an increase in the percentage of fat in the milk as the period of lactation advances.
>
> The percentage of fat in the milk decreased slightly for the second period and then gradually increased till the ninth month. For the ninth, tenth, and eleventh months the test remained practically stationary and increased again for the twelfth month.
>
> On the average the cows gave the richest milk at the end of their lactation period. An examination of the yearly record shows that a few cows for 1 year gave poorer milk when they went dry than when fresh, but in no case where the average of 2 or more years was considered do the cows depart from the average result. With some the increase in per cent of fat was much greater than with others.

Farrington,[2] when chemist to the Illinois experiment station, conducted an investigation with 6 animals for the purpose of throwing light on the influence of the stage of lactation on the chemical composition of the milk. The investigation, which was conducted through an entire lactation period, consisted of daily determinations of the weight of the milk, percentage of fat, percentage of total solids, and percentage of solids not fat. The animals represented 3 breeds, namely, Jersey, Holstein-Friesian, and Shorthorn. The feeding varied considerably during the investigation. Prof. Farrington's conclusions in his summary are:

> The butter fat was the most changeable constituent of the milk. The percentage of solids not fat was quite uniform. Both were higher in the last part of the period of lactation than in the first, when the cows were fresh and the maximum quantity of milk was produced. This was especially true of the fat. As the activity of the milk glands gradually declines until the flow of milk ceases, the formation of the fat seems to hold out better than the other constituents of the milk. A gradual increase of the grain feed from 12 to 24 pounds a day per head, and the change from stable to pasture feed, each increased the yield of milk, but had very little, if any, effect on its quality.

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[1] Linfield, F. B. Experiments with dairy cows. Utah Agricultural Experiment Station Bul. 68. Logan, June, 1900.

[2] Farrington, Edward Holyoke. Variations in milk. Illinois Agricultural Experiment Station Bull. 24. Champaign, 1893.

Simon[1] in 1900 started an investigation of the effect of the stage of lactation on the proteids of milk. Two cows were used, one a Friesian and the other a grade of Simmental Dithmarschen strain. One of these cows was on a constant ration, but the feed of the other was changed several times. The lactation periods were prolonged owing to the fact that the cows did not become pregnant until late in the period. At the end of the first year the work was continued by Trunz.[2]

Analyses were made on samples from each milking during the colostrum period and afterwards on composite samples of one day's milk taken at weekly intervals. The analyses were confined to weight of milk, specific gravity, fat by Gerber's method, total solids, total nitrogen-containing substances, total proteids, casein, albumin and globulin, and residual nitrogen. The total nitrogen was determined by the Kjeldahl method. The total proteids were determined by precipitation with tannic-acid solution. The casein was determined by the Schlossman potash-alum method. The combined albumin and globulin were determined by precipitation with tannic-acid solution in the filtrate from which the casein had been removed. The residual nitrogen was determined in the filtrate from the total proteid determination by the Kjeldahl method.

In his conclusions Trunz stated that the milk production reached its highest point several weeks after calving and then sank slowly and regularly to the end of the lactation period. The specific gravity followed the opposite course. The total solids and fat content started high, then sank until the third or fourth month, when they remained approximately constant for a time, and then rose to the end of the lactation period.

Excluding the colostrum period, the total nitrogen content remained practically constant for 6 or 7 months. It then rose gradually until it almost doubled its average value at the end of the lactation period. The total proteid content followed closely the total nitrogen content. Excluding the colostrum period, the relation of the percentage of casein to the percentage of albumin and globulin showed no decided variation, though the ratio of casein was much higher in the case of one cow than with the other. The residual nitrogen was high in the colostrum period, but did not suffer any material change.

Hittcher,[3] in 1890–91, conducted a series of investigations on 16 purebred Holstein (Hollandischen) cows, lasting through an entire period of lactation. This was a continuation of the work of Dr.

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[1] Simon, Gustav. Beitrag zur Kenntniss der Eiweisskörper der Kuhmilch. Zeitschrift für Physiologische Chemie, vol. 33, No. 5/6, pp. 466–541. Strasburg, Oct. 31, 1901.

[2] Trunz, August. Über die Schwankungen der Eiweiszstoffe der Kuhmilch im Verlaufe einer Laktation. Zeitschrift für Physiologische Chemie, vol. 39, No. 5, pp. 390–395. Strasburg, Sept. 19, 1903.

[3] Hittcher, Karl. Untersuchung der Milch von sechszehn Kühen. Landwirthschaftlicher Jahrbucher, vol. 23, pp. 873–967. Berlin, 1894.

Fleischmann, the results of which were published in 1891,[1] with the difference that the investigations were begun at the beginning of lactation and not after lactation was already in progress.

Sixteen registered cows which calved at about the same time were selected for the tests. Except for minor differences, the cows were all given the same treatment and feed, but they were not kept under the same external conditions nor on the same feed during the entire period of lactation. In several cases where there was some change in conditions there was a noticeable change in the composition of the milk.

After each milking the milk was weighed and an average sample was taken. The specific gravity of this sample was taken with a standardized lactometer (Senkwaage) 3 hours or more after the milking, and the percentage of fat was determined by means of a De Laval lactocrit. From these results an average for each month was computed. From these averages the percentage of total solids and the specific gravity of the total solids were computed by means of Fleischmann's formula. Then from the above results were computed the percentage of solids not fat and the percentage of fat in the total solids. Tables were then made and curves plotted from these results. From these the following points were noted:

1. The fat content in 10 cows was higher at the end than at the beginning of lactation. In 3 of these the increase was slight. In 6 cows the fat content was lower at the end than at the beginning, and in 4 of these the decrease was quite noticeable· In the previous investigation the fat content had increased in all but 1 cow. This is partially accounted for by the fact that the previous year the investigation began after lactation was in progress. There were some irregularities in the fat curve which were easily accounted for by changes in feed, weather, etc.
2. The percentage of solids not fat decreased noticeably in the first weeks of lactation, then it usually made an even, slightly rising curve to the end.
3. The total solids decreased rapidly in the first weeks of lactation and rose rapidly in the last weeks. In general it followed the curve of the fat content.
4. The direction of the curve of the percentage of fat in the total solids is variable. It usually descends during the first weeks, then rises. In all cases there was a rise in the curve in September, due probably to changes in external conditions.
5. The total milk production decreased from first to last.
6. In every case where there was any considerable increase in milk production there was a decrease in she percentage of fat.

Gripenberg,[2] in 1889–1891, conducted a series of investigations to find the variation in the fat content of milk during the period of lactation. The cows used for the investigation were Holstein, Ayrshire, Angler, and native. The Holstein cows were fed a uniform ration throughout the year. Individual samples and composite samples from the cows of each breed were taken weekly and fat determinations made with a Fjord centrifuge. It was found that there was an increase in fat toward the close of the lactation period.

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[1] Fleischmann, Gustav Friedrich Wilhelm. Untersuchung der Milch von sechszehn Kühen. Berlin, 1891.

[2] Gripenberg, R. Redogörelse öfver verksamheten vid Mejeriafdelningen af Försöksstationen å Mustiala Institut 1892. Redogörelser för Landtbruksekonomiska försök å Mustiala Landtbruks-och Mejerünstitut (1892) Landtbruksstyrelsens Meddelanden, No. 3, pp. 22–49. Helsingfors, 1894.

Högström[1] conducted a series of investigations extending over a period of 8 years to determine the changes in the composition of milk during the period of lactation. For the investigation he used 393 Ayrshire and native cows and obtained data from 822 lactation periods. Fat determinations by the Babcock method were made twice monthly during the period of lactation.

It was found that, if the colostrum period be omitted, the percentage of fat is high during the first month, but soon begins to decrease rapidly and continues to decrease until the third month, when it reaches its minimum value. From there on it increases gradually, reaching its maximum value at the close of lactation.

Hunziker[2] conducted an investigation with 3 animals for the purpose of studying the effect of the stage of lactation on the moisture content of butter. The breed of the animals is not stated. The ration, which excluded such feeds as would tend to influence the hard or soft fats, was uniform during the entire period of lactation. His determinations included the total proteids, the casein, the albumin, and the chemical constants of the fat.

His conclusions were as follows:

> The fresh milk drawn after calving contained as high as 13.5 per cent proteids with about equal portions of albumin and casein. At the end of the second day the per cent of albumin in the milk from all 3 cows had dropped to below 1 per cent. But both the per cent of albumin and that of casein were considerably above the normal, even at the fourteenth milking. Slight irregularities excepted, there was a rapid decrease in the per cent of albumin, casein, and total proteids during the first 7 days after calving, then a gradual decrease up to and including the second month, then the per cent remained fairly constant up to and including the fifth month. After that there was a gradual increase up to and including the eighth month, followed by a more rapid rise toward drying up.
>
> The Reichert-Meissl number and the per cent of soluble fatty acids were highest at the beginning of the period of lactation; slight irregularities excepted, they decreased as the period of lactation advanced and were lowest toward the close of the period of lactation.
>
> The insoluble fatty acids were lowest at the beginning, gradually increasing during, and were highest at the end of, the period of lactation.
>
> The fact that the Reichert-Meissl number, the soluble and the insoluble fatty acids, bear a definite relation to one another, shows clearly that the per cent of soluble and insoluble acids is affected by the period of lactation, and that the soluble acids decrease while the insoluble acids increase as the period of lactation advances.
>
> The results concerning the iodin number are irregular and, considering the relatively small number of data, do not warrant the drawing of definite conclusions as to the effect of the period of lactation on the per cent of olein in butter.

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[1] Högström, K. A. Komjölkens fetthalt, dess normala växlingar och ärftlighet. Kungliga Landtbruks-Akademiens Handlingar och Tidskrift, vol. 45, No. 3/4, pp. 137-176. Stockholm, 1906.

[2] Hunziker, Otto F. The moisture content of butter and the factors which control its variations. Indiana Agricultural Experiment Station, Twenty-first Annual Report (1908), pp. 62-63. Lafayette, 1909.

Perhaps the most extensive investigation concerning the effect of the stage of lactation on the chemical and physical composition of milk was conducted at the New York Experiment Station[1] during the years 1890 to 1894, inclusive. The work was done on milk from 14 animals of Jersey, Guernsey, American Holderness, Holstein-Friesian, Devon, and Ayrshire breeds.

The object of the investigation was many-sided, including (*a*) the effect of feed on the quality and quantity of milk, (*b*) the effect of the stage of lactation on the chemical and physical composition of milk, (*c*) the relation of the several constituents of milk to the production of butter and cheese, (*d*) the suitability of the several breeds for the different dairy products, etc. Although careful records were kept of the feed given, no definite ration was fed and no attempt made to eliminate the influence of feed.

The investigation covered 4 entire lactation periods, and, briefly summarized, the figures warrant the following conclusions:

The milk yield decreased in every case as the period of lactation advanced.

The fat yield followed the milk yield very closely. In general, the percentage of fat remained fairly constant up to the fifth month of the lactation period, then it steadily increased to the end.

The total solids, in general, after a slight decrease during the first month, showed a gradual increase as the period of lactation progressed, though the rapidity and constancy of the increase varied in different periods.

The casein suffered a slight decrease in the first month, then gradually increased up to about the last month, after which the increase was rapid up to the end of the lactation period. The percentage of casein was generally higher through the first period of lactation than in the 3 following periods.

The sugar was the most variable of the milk constituents. The general averages for all periods showed a decrease, followed by about an equal increase up to the tenth month, when there was a marked decrease to the end of the lactation period. This does not, however, hold true for each separate period; e. g., the percentage of sugar during the first lactation period tended to increase during lactation; during the second and third periods it followed the general average, while during the fourth period it tended to remain constant.

The percentage of ash according to the general average remained fairly constant throughout the lactation period, despite a few variations according to the period.

The physical composition depends largely upon the breed of the animal. There is, however, one general rule—the relative number of small fat globules steadily increases, with a corresponding decrease in the relative number of the large fat globules, as the period of lactation progresses. The total number of fat globules also greatly increases. The percentage of total small fat globules increased 68 per cent in the second period over the first, while the largest globules decreased 67 per cent in the second period over the first, and at the same time the intermediate-sized globules decreased to 83 per cent of what they were in the first. There was a similar change in the third period over the second. The physical changes from period to period are closely analogous to the physical changes from month to month of each lactation period.

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[1] New York Agricultural Experiment Station. Ninth, Tenth, Eleventh, Twelfth, and Thirteenth Annual Reports, Geneva, 1890 to 1894.

THE PRESENT EXPERIMENTS.

PURPOSE AND PLAN OF THE INVESTIGATION.

A review of the references made to the previous investigations regarding the effect of the stage of lactation will show that in no case were the conditions controlled to the extent of eliminating other possible causes for the variations found. It has been demonstrated that the nature of the feed has an important influence on milk, especially in regard to the composition of the fat. For this reason it is not safe to conclude that certain results obtained are to be attributed to the stage of lactation, if the ration varies from the dry feed of winter to green pasture grass of summer, as has been the case in some investigations. In planning our investigation we attempted to control these factors more completely. While the effect of the stage of lactation was the main factor under consideration, the plans were so made that the influence of breed and individuality could be studied at the same time from the data secured. Twelve animals were selected for the tests, as it was believed that this number would be sufficient to eliminate variations due to individuality of the animal and make it possible to draw correct general conclusions regarding the influence of the stage of lactation. Four breeds were selected in order that the relation of breed to variations caused by the stage of lactation could be observed and, further, that the breed characteristics could be studied at the same time.

The general plan was as follows: Twelve animals were to be used, namely, 3 each of the Holstein-Friesian, Ayrshire, Shorthorn, and Jersey breeds, the animals to be as near as possible typical specimens for the breeds—that is to say, neither inferior nor superior producers of milk, but approximately the average, or a little above, for the breed. The animals used were all purebred and registered. They were fed and cared for throughout the entire experiment under much the same conditions as would be found in a commercial dairy, except regarding the control of the feed and animals. One of the Ayrshires reacted to the tuberculin test and was put out of the experiment soon after the beginning. Table 1 gives the data in detail regarding the 11 cows that were used throughout a complete lactation period.

The milking was done by a student of the agricultural college, the precaution being taken to change milkers as little as possible. In most cases not more than one change was made during the entire milking period of the animal.

The date of beginning the sampling for analysis was that ordinarily followed in practical dairies, five days after the birth of the calf, if the cow and the milk seemed normal. The sampling was continued until the production of milk was reduced to the point where in a commercial dairy the cow would not be milked longer. The purpose in view was to give these animals such treatment as they would receive in the hands of a practical dairyman where the product was used for market milk or other purposes.

It was contemplated having the cows bred at such times as would usually be practiced in a commercial dairy in order that the next calf might be born at approximately a year from the beginning of the lactation period covered by the experiment. With some of the animals the interval between the birth of the calves was somewhat longer and in others shorter, and one of the Jersey cows, No. 118, would not breed and remained farrow throughout the period covered by the investigation. It is not unusual for this to occur with Jersey cows at the age of this cow and could not be attributed in any way to the ration given. With this exception the animals apparently remained in normal healthy condition, as shown by those indications which are usually taken to denote thrift and health, and they have since shown no ill effects from the treatment given them. The oestrum periods of the cows were as regular as usual while on the experimental ration, and the calves born later were strong and vigorous and rather larger than the average for the breeds represented.

The total yield of milk and of fat for the animals was in most cases somewhat less than the amount produced by them in previous lactation periods. However, the production during the experimental periods was more than the average of the breeds represented, and for this reason it is believed that the conditions were sufficiently normal to make the results reliable.

In addition to the 11 cows carried through an entire period of lactation, data are given of the composition throughout the lactation period of the milk of 5 Jersey cows used in another investigation. The latter differed from the 11 cows in being farrow, and they were not kept on a uniform ration.

THE FEED RATION.

The main feature of the experiment was to maintain the animals throughout the entire lactation period on an absolutely uniform ration, and at the same time keep the animals in a perfectly normal condition. A number of difficulties at once occur to the practical feeder in arranging to carry out such a plan. For instance, it is not possible to select any one ration which will be ideal for all stages of the lactation period. In the first part, when a large quantity of milk is being produced, the animal requires more concentrated feed in proportion to the roughness for the best results than at the latter part, and it is the common practice to make such a distinction in feeding. The experienced feeder supplies his animals with practically the same amount of roughness throughout the lactation period, but a larger amount of grain is fed in the early part of the period than toward the end. This practice in feeding arises from the fact that a certain amount of bulky food must be consumed by the cow at all times on account of the nature of the digestive apparatus. Any uniform ration to be fed throughout a lactation period must therefore of necessity be a compromise. This means that in the early stages of the lactation period such a ration will contain rather too much roughness in proportion to the grain, while at the latter part the reverse will be true.

In planning for this investigation it was also necessary that a ration be selected that could be secured at all times throughout a period of two or three years required to complete the work. Furthermore, such a ration must be palatable in order that the animals will relish it at all times and not become tired of it. After careful consideration the ration selected for this purpose was as follows:

Choice alfalfa hay	3 parts.
Grain (corn, 8 parts; bran, 1 part; oats, 1 part)	2 parts.

This ration supplied the protein and carbohydrates in approximately the proportions found by experience to give good results for milk production. The amount of grain was made rather large in proportion to the hay to make sure that the entire ration would be consumed at all times. The ratio between the feeding stuffs composing the ration was kept exactly the same all the time and the entire amount fed varied in proportion to the needs of the animal.

It would have been better had it been feasible to feed a certain amount of corn silage during this experiment, but the probability that at times it would not be possible to secure this food, and furthermore the wide variations in composition, prevented it from being used. The animals fared well on the ration as fed and showed no ill effects from lack of variety. Only a few times in carrying the animals through an entire lactation period were any of them "off feed," and these animals were easily brought to a normal condition by giving a dose of Epsom salt. In no case was there any serious sickness of any kind. Two of the Ayrshire cows were fed through two complete periods on this same ration with no change.

The hay, the most variable part of the ration in composition, was bought in large quantities from the same source in order that there might be but a few changes in its composition. The cows were housed in the manner common to this locality, by tying them at night in a barn for feeding and milking where the temperature was moderate; in the daytime they were turned outside and kept in a dry lot with no chance of securing feed other than that supplied. They were fed twice a day, the ration for the day being divided into two equal parts.

METHOD OF SAMPLING AND PREPARATION OF SAMPLES FOR ANALYSIS.

Special care was taken that the sample which reached the laboratory fairly represented the milk from the animal in question.

The milk was weighed after milking and mixed by pouring from one pail to another. A sample of about 1 liter was placed in a glass jar bearing the number of the cow and the number of pounds of milk for that particular milking, and delivered to the laboratory. A certain number of cubic centimeters per pound of milk were then measured out and placed in a closed receptacle to make up a composite sample to represent a week's milk from that particular cow. The number of cubic centimeters per pound was regulated by the amount of milk yielded, and varied with the individual and the amount of milk produced. As the milk flow diminished, the proportion taken for a sample increased in order that the actual volume of the composite sample might remain to insure a quantity of fat sufficient for analysis. The changes in the cubic centimeters per pound taken were always made at the beginning of a week. Formaldehyde in solution as formalin was added in amounts sufficient to preserve the sample for the 7-day period. The amount varied from 1 part formaldehyde to 5,000 parts milk to 1 part to 2,500 parts, depending upon the season of the year. When the composite sample for the week was complete it was thoroughly mixed and a subsample of about 300 cubic centimeters taken for analysis.

The remainder of the composite sample was heated to the proper temperature and the cream separated by means of a small hand-power separator. Since it was found the subsequent churning of the cream was retarded by the presence of formaldehyde, the cream was diluted with a quantity of warm water equal in volume to the skim milk removed, and again separated. The cream so obtained, usually about a liter in quantity, was churned by shaking in a glass jar of about 2 liters capacity.

The question arose at the outset of the work as to whether the butterfat so .obtained represented the butterfat originally in the milk or whether the small fat globules known to have escaped in the skim and butter milk were of different chemical and physical composition from those which ultimately collected as butter. On account of the conflicting evidence on this point it seemed advisable to carry on some investigation along this line before proceeding further. The results of this work, which are published as Bulletin 111, Bureau of Animal Industry, United States Department of Agriculture, showed that there was no difference in composition between the various-sized fat globules, and therefore the fat obtained by the above procedure may be taken as truly representative of the butterfat in the milk.

The butter was immediately melted on a steam bath and allowed to remain in this condition until the curd and water had settled. Special care was taken at this point that the temperature of the fat did not rise above 50° to 55° C. and also that it remained even at this temperature no longer than was necessary.[1] It was then filtered through a paper filter kept warm by an electrical device and preserved in corked bottles which were protected from light in a refrigerator until analyzed.

METHODS OF ANALYSIS.

During the preliminary work a tendency was noticed of the subsamples of milk to churn. This was particularly true of the milk from the Jersey cows. To avoid this the procedure was followed of removing the charges for all the determinations at the same time, including the specific gravity, the remainder of the subsample being stored in the refrigerator as a reserve sample.

According to the original plan each series of determinations was to be made by the same chemist and this plan was followed with but few exceptions during the whole investigation.

The analytical methods followed were those of the Association of Official Agricultural Chemists whenever possible. Duplicate determinations were made in all cases, and in some cases triplicate or even quadruplicate Only the briefest description of the official method is given below. For a detailed description reference may be made to Bulletin 107 (revised) of the Bureau of Chemistry, United States Department of Agriculture.[2]

Specific gravity.—The specific gravity was determined by means of a Westphal balance.

Total nitrogen.—The total nitrogen was determined by the Gunning method.

Casein nitrogen.—The casein nitrogen was determined by the official method of precipitating the casein with 10 per cent acetic-acid solution and determining the nitrogen in the precipitate by the Gunning method.

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[1] According to C. A. Brown (Annual Report of the Pennsylvania State College, 1899–1900, p. 208) a temperature much above 50° C. will very soon alter the composition of butterfat. Butterfat kept at 50° C. for two days showed a loss of over one unit in iodin number.

[2] For the benefit of those who may be unfamiliar with some of the terms the following explanation may be helpful: The Reichert-Meissl number is an arbitrary measure of the volatile acids, of which butyric is the principal one in butterfat. The figures do not show the percentages of the acid, but serve as a means of comparing different fats with reference to their volatile constituents. The iodin absorption number indicates relatively the amount of iodin a fat will absorb. Since the only fatty acid found to exist in butterfat which has the property of absorbing iodin is oleic acid, the iodin absorption number shows relatively the amount of this fatty acid present, but, in common with the Reichert-Meissl number, the figures do not represent percentages. The saponification number is the number of milligrams of potassium hydroxid required to saponify 1 gram of fat. Since the amount of potassium hydroxid required depends upon the molecular weight of the fat, the saponification number serves as an indicator of the relative percentages of the fatty acids of high and low molecular weights present.

Albumin nitrogen.—The albumin nitrogen was determined by the provisional method of coagulating the albumin by heating the filtrate from the casein nitrogen determination and determining the nitrogen in the coagulum by the Gunning method.

Total solids.—The total solids were determined by the official method known as the Babcock asbestos method, employing a hollow copper cylinder and woolly asbestos.

Fat.—The fat was determined by the official Babcock asbestos method. The cylinders containing the residue from the total solids determination are extracted with ether in Soxhlet extractors, the heat being supplied by an electrical device.

Sugar.—The sugar was determined by the official optical method, using acid mercuric nitrate as the defecating agent and a Schmidt and Haensch half-shadow polariscope.

Relative size of fat globules.—The relative size of the fat globules was determined by the Babcock capillary tube method. A $\frac{1}{6}$-inch objective and 1-inch ocular provided with a micrometer were employed. The value of each division of the micrometer scale is 0.00258 millimeter. This method is described in detail in Bulletin 111, Bureau of Animal Industry, United States Department of Agriculture.

Melting point of the butterfat.—The melting point was determined according to Wiley's method, by placing a disk of the fat in a large test tube containing boiled distilled water and boiled alcohol which had been cooled, the tube being placed in a beaker of water which was slowly heated, and noting, by means of a thermometer graduated to 0.1° C., the temperature at which the disk assumed the form of a sphere.

Refractive index of the butterfat.—The refractive index was determined with a Zeiss-Abbe refractometer which had been standardized with distilled water. The fat was kept at a constant temperature above its melting point during the determination by means of a current of warm water circulating through the instrument. The reading was reduced later by means of a factor to 25° C.

Volatile acids of the butterfat.—The method of Reichert, modified by Meissl, was employed in the estimation of the volatile acids, and the results are given as Reichert-Meissl numbers. In saponiying, use was made of the Leffman-Beam method, in which the fat is saponified in a flask over a naked flame with a mixture of a strong aqueous solution of caustic soda and pure glycerol. The soap obtained in this way is decomposed by sulphuric acid and the liberated volatile acids are distilled over with the steam and titrated with decinormal barium hydroxid solution.

Saponification value of the butterfat.—The saponification value, or Koettstorfer number, was determined by the regular official method.

The fat is saponified in a flask on a steam bath with an alcoholic potash solution, using a long glass as a reflux condenser.

Iodin absorption number of the butterfat.—The method of Hubl was employed in this case. The fat is dissolved in chloroform and subjected to the action of a mixture of an alcoholic solution of iodin and of mercuric chlorid in a dark place for 3 hours, at the end of which time the unabsorbed iodin is determined by titrating with standard sodium thiosulphate solution. The percentage of iodin absorbed by the fat is expressed in the results as the iodin number.

RESULTS OF THE EXPERIMENTS.

In presenting the results of this investigation it was decided to base the discussions mostly upon tables representing periods of 4 weeks each. All figures given for 4-week periods are the average of 4 analyses, each of which represents a sample made up, as before described, from all the milk produced in 1 week. The object in using an average representing periods of 4 weeks is that the weekly tables giving the original analyses are too unwieldy for studying the general effect of the lactation period. It is believed that the 4-week period is long enough to eliminate the daily and weekly variations which, as far as our present knowledge goes, are impossible to control and is at the same time short enough to illustrate those changes which it is the purpose of this bulletin to show. The original data giving the analyses of weekly samples from which the other tables are compiled are found in the appendix at the end of this bulletin.

In general, the data are presented in two ways, one in which the changes in the amount of each milk component during the lactation period may be studied, and the other in which the relation of each component to the others during the lactation is shown. It is the plan to eliminate as far as practicable references to the effect of breed and individuality on the chemical and physical composition of milk, this being reserved for another bulletin, which will present the same data in a way to illustrate especially this effect.

Table 1 gives the general data regarding the animals used. their age, yield of milk and fat, date of breeding, etc.

Table 2 gives the yield of milk and of fat for each cow by 4-week periods throughout the lactation period.

Table 3 gives the total yield in pounds of the several milk constituents for each animal during the lactation period.

Table 4 gives the true average composition of the milk of each cow for the entire milking period. Since both the quantity and the composition vary, a direct average from analyses made at intervals is often misleading. Most of the constituents increase greatly at the end of the milking period and at the same time the yield of milk is small. A direct average, therefore, gives a figure much higher than would be found had all the milk been gathered and sampled at one time. This error is reduced to the minimum by calculating the total weight of each constituent by periods and dividing the total produced by the total milk. Whenever an average figure is used in this report for the nitrogen, fat, sugar, or total solids the true average is meant. In considering the physical constants of the fat a direct average is used, since they vary but little and the error from such an average is too small to be of any importance.

Table 5 gives the average analysis of the milk of each cow for the complete lactation period by 4-week periods.

TABLE 1.—*Data concerning the cows used.*

No. of cow.	Breed.	Age.		Date of calving.	Date of breeding.	Period samples were taken.	Total yield of milk.	Average fat.	Total yield of fat.
		Ys.	*m.*				*Lbs.*	*P. ct.*	*Lbs.*
4	Jersey....	6	10	Nov. 13, 1906	Dec. 30, 1906	Nov. 24, 1907, to Sept. 7, 1908	5,429	4.87	264.45
99	...do......	8	1	Jan. 1, 1907	Mar. 23, 1907	Jan. 5, 1907, to Nov. 30, 1907	6,115	4.64	284.04
118	...do......	11	4	Sept. 27, 1906	Not bred.	Oct. 6, 1906, to Oct. 26, 1907	5,733	5.36	307.45
205	Holstein.	5	3	July 17, 1907	Dec. 1, 1907	July 20, 1907, to Aug. 8, 1908	8,684	3.24	280.76
206	...do......	5	0	May 31, 1907	Sept. 28, 1907	June 1, 1907, to Apr. 4, 1908	8,994	2.93	263.66
209	...do......	3	8	July 20, 1907	Nov. 18, 1907	July 20, 1907, to July 4, 1908	8,814	3.02	273.34
300	Ayrshire.	3	8	Dec. 28, 1907	Feb. 23, 1908	Dec. 29, 1907, to Oct. 3, 1908	6,275	3.51	220.34
301	...do.....	4	8	Sept. 27, 1907	Mar. 16, 1908	Sept. 29, 1907, to Sept. 19, 1908	6,382	3.85	245.64
400	Shorthorn	4	4	Sept. 30, 1907	Jan. 25, 1908	Oct. 5, 1907, to Aug. 1, 1908	5,172	3.89	201.37
402	...do.....	4	11	Oct. 13, 1907	Dec. 21, 1907	Oct. 19, 1907, to July 18, 1908	4,449	4.13	183.57
403	...do......	6	0	Feb. 11, 1908	July 7, 1908	Feb. 15, 1908, to Dec. 19, 1908	6,539	3.35	220.52

TABLE 2.—*Milk and butterfat produced by each cow, and average for each breed, by 4-week periods.*

Cow No.	First period.		Second period.		Third period.		Fourth period.		Fifth period.		Sixth period.		Seventh period.	
	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
4............	770.8	39.80	738.4	34.18	557.7	28.07	556.2	26.96	578.8	27.85	471.9	23.56	476.0	22.50
99...........	708.9	37.02	690.1	33.02	701.0	31.05	628.7	27.62	518.9	22.41	550.0	23.21	490.2	21.37
118..........	428.4	......	376.2	......	423.9	23.41	475.7	24.34	418.9	23.09	440.2	25.15	449.7	25.57
Average for Jerseys....	636.0	38.41	601.6	33.60	560.9	27.51	553.5	26.31	505.5	24.45	487.4	23.97	472.0	23.15
205..........	788.0	25.05	860.8	27.06	827.5	24.94	750.4	24.28	742.9	24.45	690.7	21.12	666.1	21.70
206..........	1,360.6	41.61	1,267.1	36.62	970.5	25.00	872.4	24.79	858.1	24.77	773.3	23.68	718.5	20.72
209..........	1,026.1	30.81	1,086.5	28.19	940.9	25.72	818.5	26.64	711.7	22.22	724.7	20.35	700.3	20.60
Average for Holsteins.	1,058.2	32.49	1,071.5	30.62	913.0	25.22	813.8	25.24	770.9	23.81	729.6	21.72	695.0	21.01
300..........	837.9	33.53	871.8	31.37	869.0	29.35	778.5	26.18	741.7	24.60	738.1	24.04	576.3	19.08
301..........	612.3	23.42	582.6	21.80	539.4	20.53	570.5	21.72	533.1	21.77	595.7	22.49	572.4	22.60
Average for Ayrshires.	725.1	28.48	727.2	26.59	704.2	24.94	674.5	23.95	637.4	23.18	666.9	23.27	574.4	20.84
400..........	680.9	27.99	662.6	27.11	456.6	18.25	501.7	18.33	565.9	20.92	538.8	19.86	501.2	19.23
402..........	647.1	29.44	576.3	24.05	532.0	21.13	518.7	19.70	512.3	19.68	486.0	19.00	437.6	17.40
403..........	909.7	32.43	859.8	29.05	829.9	26.33	768.1	24.25	681.4	21.43	625.9	19.56	569.9	18.42
Average for Shorthorns	745.9	29.95	699.6	26.74	606.2	21.90	596.2	20.76	586.5	20.68	550.2	19.47	502.9	18.35

TABLE 2.—*Milk and butterfat produced by each cow, and average for each breed, by 4-week periods*—Continued.

Cow No.	Eighth period.		Ninth period.		Tenth period.		Eleventh period.		Twelfth period.		Thirteenth period.		Fourteenth period.	
	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.	Milk.	Fat.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
4	446.6	20.13	378.7	17.92	454.4	23.48	......	......	......	......	......	......	......	......
99	494.5	20.70	484.1	22.38	446.0	22.14	280.7	15.71	122.1	7.41	......	......	......	......
118	413.3	23.97	456.0	23.58	469.3	21.04	446.7	21.56	417.8	22.01	366.3	20.02	150.9	9.74
Average for Jerseys	451.5	21.60	439.6	21.29	456.6	22.22	363.7	18.64	270.0	14.71	366.3	20.02	150.9	9.74
205	640.4	20.78	648.1	20.38	598.7	19.78	574.4	18.97	445.2	15.55	311.6	11.50	139.7	5.20
206	701.4	20.99	682.4	20.42	561.2	17.31	228.9	7.75	......	......	......	......	......	......
209	717.0	21.59	711.5	21.39	520.3	18.28	477.7	16.35	273.4	10.65	......	......	......	......
Average for Holsteins	686.3	21.12	680.7	20.73	560.1	18.46	427.0	14.36	359.3	13.10	311.6	11.50	139.7	5.20
300	435.8	15.42	303.1	11.20	123.6	5.57	......	......	......	......	......	......	......	......
301	531.1	20.90	566.0	20.77	587.7	21.03	332.9	14.21	235.0	9.30	123.7	5.10	......	......
Average for Ayrshires	483.5	18.16	434.6	15.99	355.6	13.30	332.9	14.21	235.0	9.30	123.7	5.10	......	......
400	517.9	19.32	424.6	17.05	217.7	9.01	103.3	4.30	......	......	......	......	......	......
402	392.6	15.31	246.9	13.45	99.5	4.41	......	......	......	......	......	......	......	......
403	477.5	16.87	368.8	14.17	273.4	10.94	......	......	......	......	......	......	......	......
Average for Shorthorns	462.7	17.17	346.8	14.89	196.9	8.12	103.3	4.30	......	......	......	......	......	......

TABLE 3.—*Total yield of milk and milk constituents by each cow.*

Cow No.	Total milk.	Total solids.	Fat.	Nitrogen.							Sugar.	Ash.
				Total nitrogen.	Protein (N× 6.38).	Casein nitrogen.	Casein (N× 6.38).	Albumin nitrogen.	Albumin (N× 6.38).	Residual nitrogen.		
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
4	5,430	764.6	264.5	31.5	200.7	25.2	160.7	3.6	19.5	2.7	263.7	38.0
99	6,115	821.5	284.0	31.4	200.4	25.4	162.4	2.4	15.3	3.6	302.8	45.3
118	5,733	850.5	307.5	35.7	227.6	28.2	179.8	3.7	23.6	3.8	275.3	42.4
205	8,685	1,042.7	280.8	40.9	260.8	33.5	213.9	2.9	18.5	4.5	438.7	56.4
206	8,994	964.1	263.7	38.1	243.0	29.8	190.4	3.1	19.6	5.2	383.3	63.0
209	8,815	997.1	273.3	44.3	282.8	34.8	221.9	3.9	24.8	5.6	375.0	61.7
300	6,276	757.9	220.3	30.6	195.1	25.9	164.9	1.8	11.8	2.9	304.6	40.2
301	6,382	811.5	245.6	33.3	212.4	27.8	177.2	2.4	15.4	3.1	316.5	38.9
400	5,171	676.2	201.4	27.6	175.8	22.4	143.0	2.4	15.4	2.8	260.6	37.8
402	4,449	599.0	183.6	24.3	155.3	19.9	126.9	2.1	13.2	2.3	218.5	32.5
403	6,540	796.0	220.5	33.6	214.6	26.8	170.7	3.2	20.3	3.6	326.0	45.1

TABLE 4.—*True average composition of the milk of each cow.*

Cow No.	Average total solids.	Average solids not fat.	Average total nitrogen.	Average protein.	Average casein nitrogen.	Average casein.	Average albumin nitrogen.	Average albumin.	Average residual nitrogen.	Average fat.	Average sugar.	Average ash.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4.....	14.08	9.21	0.58	3.70	0.46	2.95	0.056	0.359	0.064	4.87	4.85	0.70
99....	13.43	8.79	.51	3.27	.42	2.65	.039	.249	.051	4.64	4.95	.74
118...	14.83	9.47	.62	3.97	.49	3.14	.064	.411	.066	5.36	4.80	.74
205...	12.00	8.80	.47	3.00	.39	2.46	.033	.213	.047	3.23	5.05	.65
206...	10.70	7.80	.42	2.70	.33	2.12	.034	.218	.056	2.93	4.26	.70
209...	11.30	8.20	.50	3.21	.39	2.52	.044	.281	.066	3.10	4.25	.70
300...	12.10	8.60	.49	3.11	.41	2.63	.029	.188	.051	3.51	4.85	.64
301...	12.70	8.90	.52	3.33	.44	2.78	.038	.241	.042	3.85	4.96	.61
400...	13.10	9.20	.53	3.40	.43	2.77	.047	.297	.053	3.89	5.04	.73
402...	13.50	9.30	.55	3.49	.45	2.85	.046	.296	.054	4.13	4.91	.73
403...	12.20	8.80	.51	3.28	.41	2.61	.049	.310	.042	3.37	4.98	.69

TABLE 5.—*Average analysis of the milk of each cow, by 4-week periods.*

COW NO. 4.

Four weeks ending—	Specific gravity of milk.	Water.	Total solids.	Solids not fat.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Sugar.
1906.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dec. 22..............	1.0345	85.87	14.13	9.51	0.52	0.44	0.059	5.17	4.89
1907.									
Jan. 19..............	1.0330	....	....	....	.53	.38	.056	4.63	4.99
Feb. 16..............	1.0338	....	....	....	.57	.48	.057	5.07	4.87
Mar. 16..............	1.0340	85.56	14.44	9.51	.61	.49	.067	4.85	5.28
Apr. 13..............	1.0338	85.72	14.28	9.10	.60	.48	.045	4.81	5.12
May 11..............	1.0337	85.85	14.15	8.90	.59	.48	.031	5.00	5.00
June 8..............	1.0326	86.13	13.87	9.14	.59	.47	.064	4.73	4.39
July 6..............	1.0327	86.23	13.77	9.41	.57	.46	.061	4.51	4.45
Aug. 3..............	1.0334	86.38	13.63	9.02	.62	.50	.062	4.73	4.67
Sept. 7 [1]............	1.0338	85.43	14.57	9.39	.66	.52	.063	5.18	4.60

COW NO. 99.

Four weeks ending—	Specific gravity of milk.	Water.	Total solids.	Solids not fat.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Sugar.
1907.									
Feb. 2..............	1.0329	....	....	....	0.51	0.42	0.038	5.22	4.94
Mar. 2..............	1.0327	86.91	13.09	8.72	.51	.41	.054	4.79	5.15
Mar. 30..............	1.0333	86.71	13.30	8.86	.51	.40	.037	4.43	5.17
Apr. 27..............	1.0326	86.85	13.15	8.75	.49	.40	.025	4.40	5.05
May 25..............	1.0322	87.09	12.92	8.59	.49	.40	.029	4.33	5.04
June 22..............	1.0314	87.24	12.76	8.54	.49	.40	.043	4.22	4.50
July 20..............	1.0310	86.96	13.04	8.77	.48	.39	.036	4.36	4.52
Aug. 17..............	1.0322	87.19	12.81	8.63	.50	.40	.041	4.18	5.14
Sept. 14..............	1.0328	86.65	13.35	8.72	.52	.42	.035	4.63	4.62
Oct. 12..............	1.0337	85.74	14.27	9.29	.56	.46	.043	4.98	5.03
Nov. 9..............	1.0343	84.85	15.15	9.54	.62	.51	.042	5.62	5.02
Nov. 30..............	1.0343	83.92	16.08	10.01	.66	.53	.071	6.07	5.61

COW NO. 118.

Four weeks ending—	Specific gravity of milk.	Water.	Total solids.	Solids not fat.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Sugar.
1906.									
Nov. 3..............	....	....	....	....	....	....	....	....	....
Dec. 1..............	1.0302	85.92	14.08	8.77	0.51	0.32	0.081	5.31	4.47
Dec. 29..............	1.0302	85.45	14.55	8.97	.56	.48	.051	5.55	4.70
1907.									
Jan. 26..............	1.0324	....	....	....	.54	.42	.057	5.11	4.56
Feb. 23..............	1.0340	....	....	....	.65	.54	.074	5.51	4.83
Mar. 23..............	1.0345	84.70	15.30	9.59	.65	.52	.071	5.71	5.21
Apr. 20..............	1.0344	84.84	15.16	9.44	.67	.54	.049	5.69	5.20
May 18..............	1.0346	84.39	15.61	9.81	.64	.54	.057	5.80	5.40
June 15..............	1.0341	85.21	14.79	9.63	.64	.51	.062	5.17	4.57
July 13..............	1.0336	85.55	14.45	9.67	.64	.50	.069	4.47	4.73
Aug. 10..............	1.0349	85.58	14.42	9.65	.65	.51	.062	4.83	4.90
Sept. 7..............	1.0356	84.92	15.08	9.80	.70	.55	.065	5.28	4.72
Oct. 5..............	1.0361	83.90	16.10	10.67	.75	.61	.061	5.48	4.46
Oct. 26 [2]............	1.0355	82.84	17.16	10.70	.77	.58	.062	6.47	5.22

[1] Last period, five weeks.

[2] Last period, three weeks.

TABLE 5.—*Average analysis of the milk of each cow, by 4-week periods*—Continued.

COW NO. 205.

Four weeks ending—	Specific gravity of milk.	Water.	Total solids.	Solids not fat.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Sugar.
1907.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Aug. 17	1.0338	88.26	11.74	8.50	0.49	0.40	0.041	3.24	4.69
Sept 14	1.0327	88.43	11.58	8.43	.43	.35	.032	3.14	4.98
Oct. 12	1.0328	88.30	11.70	8.68	.44	.34	.031	3.02	4.84
Nov. 9	1.0326	88.05	11.95	8.70	.44	.36	.032	3.25	5.18
Dec. 7	1.0325	87.89	12.11	8.82	.45	.37	.034	3.29	5.42
1908.									
Jan. 4	1.0330	88.23	11.77	8.96	.45	.38	.032	3.06	5.37
Feb. 1	1.0327	88.02	11.98	8.72	.45	.37	.037	3.26	5.20
Feb. 29	1.0333	87.84	12.16	8.92	.44	.37	.036	3.25	4.76
Mar. 28	1.0329	88.06	11.95	8.80	.48	.38	.027	3.15	5.10
Apr. 25	1.0322	87.89	12.12	8.81	.48	.39	.032	3.31	5.12
May 23	1.0329	87.81	12.20	8.89	.51	.43	.035	3.31	5.13
June 20	1.0335	87.50	12.50	9.01	.55	.45	.038	3.49	5.02
July 18	1.0331	86.97	13.04	9.36	.59	.51	.025	3.68	4.89
Aug. 8	1.0333	86.58	13.42	9.74	.65	.57	.027	3.68	4.81

COW NO. 206.

1907.									
June 29	1.0294	89.05	10.95	7.88	0.44	0.34	0.042	3.07	4.07
July 27	1.0293	89.90	10.10	7.47	.38	.30	.028	2.88	4.49
Aug. 24	1.0294	89.82	10.18	7.60	.37	.29	.030	2.58	4.44
Sept. 21	1.0281	89.74	10.27	7.42	.39	.30	.022	2.84	4.12
Oct. 19	1.0295	89.46	10.54	7.66	.42	.32	.028	2.89	4.26
Nov. 16	1.0289	89.27	10.73	7.67	.42	.33	.034	3.06	4.04
Dec. 14	1.0288	89.25	10.75	7.87	.41	.31	.040	2.88	4.74
1908.									
Jan. 11	1.0291	89.20	10.80	7.80	.43	.33	.036	3.00	4.25
Feb. 8	1.0302	88.99	11.01	8.02	.44	.36	.036	3.00	4.09
Mar. 7	1.0316	88.10	11.90	8.81	.51	.42	.039	3.09	3.94
Apr. 4	1.0345	86.70	13.30	9.78	.71	.58	.065	3.40	4.50

COW NO. 209.

1907.									
Aug. 17	1.0318	88.76	11.24	8.12	0.50	0.39	0.051	3.12	4.40
Sept. 14	1.0305	89.77	10.23	7.63	.45	.34	.032	2.60	4.00
Oct. 12	1.0300	89.37	10.63	7.90	.45	.34	.037	2.74	4.17
Nov. 9	1.0299	88.93	11.07	8.05	.47	.36	.038	3.24	3.95
Dec. 7	1.0297	88.85	11.15	8.02	.45	.35	.034	3.14	4.42
1908.									
Jan. 4	1.0303	89.05	10.96	8.14	.46	.36	.042	2.81	4.36
Feb. 1	1.0305	88.80	11.20	8.27	.50	.39	.044	2.94	4.16
Feb. 29	1.0306	88.78	11.23	8.46	.49	.40	.047	3.01	3.94
Mar. 28	1.0313	88.42	11.58	8.57	.52	.41	.038	3.01	4.43
Apr. 25	1.0325	87.42	12.58	9.06	.60	.49	.057	3.52	4.62
May 23	1.0344	87.02	12.99	9.53	.65	.53	.063	3.46	4.79
June 22	1.0348	86.49	13.51	9.61	.73	.59	.084	3.90	4.15
July 4[1]	1.0322	85.48	14.52	9.25	.71	.58	.067	5.28	4.30

COW NO. 300.

1908.									
Jan. 25	1.0329	86.93	13.07	9.06	0.53	0.44	0.039	4.01	5.14
Feb. 22	1.0325	87.73	12.27	8.66	.47	.40	.031	3.61	4.81
Mar. 21	1.0326	87.86	12.14	8.76	.48	.40	.027	3.38	4.64
Apr. 18	1.0308	88.19	11.81	8.45	.47	.38	.030	3.36	4.87
May 16	1.0313	88.35	11.66	8.34	.46	.39	.031	3.32	4.96
June 13	1.0302	88.66	11.35	8.09	.47	.39	.029	3.26	4.57
July 11	1.0300	88.62	11.38	8.07	.46	.39	.029	3.30	4.82
Aug. 8	1.0309	87.86	12.15	8.62	.49	.44	.019	3.53	5.08
Sept. 5	1.0320	87.44	12.56	8.82	.57	.52	.017	3.74	5.13
Oct. 3	1.0319	86.15	13.85	9.33	.67	.59	.032	4.52	4.39

[1] Last period, two weeks.

TABLE 5.—*Average analysis of the milk of each cow, by 4-week periods*—Continued.

COW NO. 301.

Four weeks ending—	Specific gravity of milk.	Water.	Total solids.	Solids not fat.	Total. nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Sugar.
1907.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Oct. 26	1.0343	86.80	13.20	9.31	0.56	0.47	0.043	3.87	5.17
Nov. 23	1.0327	87.51	12.50	8.76	.50	.40	.032	3.74	4.72
Dec. 21	1.0326	87.43	12.57	8.76	.48	.39	.042	3.81	5.62
1908.									
Jan. 18	1.0324	87.37	12.64	8.83	.51	.43	.035	3.81	5.16
Feb. 15	1.0328	86.91	13.09	9.01	.51	.43	.042	4.08	4.77
Mar. 14	1.0331	87.15	12.86	9.08	.53	.43	.046	3.78	4.43
Apr. 11	1.0324	87.37	12.63	8.70	.51	.42	.043	3.95	5.38
May 9	1.0320	87.36	12.64	8.70	.50	.42	.036	3.94	5.13
June 6	1.0321	87.51	12.49	8.82	.53	.45	.033	3.67	4.85
July 4	1.0310	88.22	11.78	8.21	.53	.43	.036	3.58	4.88
Aug. 1	1.0289	86.46	13.55	8.63	.53	.46	.033	4.92	4.89
Aug. 29	1.0318	86.96	13.04	9.08	.57	.52	.024	3.96	5.04
Sept. 19	1.0343	86.43	13.27	9.09	.65	.57	.032	4.18	5.13

COW NO. 400.

1907.									
Nov. 2	1.0355	86.29	13.71	9.60	0.54	0.45	0.055	4.12	5.40
Nov. 30	1.0332	86.71	13.29	9.20	.51	.41	.053	4.09	5.06
Dec. 28	1.0333	86.95	13.05	9.06	.46	.38	.033	3.99	5.44
1908.									
Jan. 25	1.0330	87.52	12.48	8.84	.48	.38	.043	3.65	5.13
Feb. 22	1.0343	86.94	13.06	9.37	.53	.44	.045	3.70	4.87
Mar. 21	1.0340	86.95	13.05	9.36	.54	.44	.043	3.69	4.95
Apr. 18	1.0341	87.04	12.96	9.11	.56	.45	.057	3.85	5.05
May 16	1.0344	86.92	13.08	9.35	.56	.46	.046	3.73	5.19
June 13	1.0329	86.97	13.03	8.98	.58	.45	.046	4.05	4.65
July 11	1.0304	87.57	12.43	8.28	.60	.48	.038	4.16	4.22
Aug. 1	1.0298	87.16	12.84	8.67	.59	.53	.027	4.17	4.25

COW NO. 402.

1907.									
Nov. 16	1.0341	86.27	13.74	9.19	0.53	0.44	0.051	4.55	4.77
Dec. 14	1.0336	86.71	13.29	9.12	.52	.43	.049	4.17	5.32
1908.									
Jan. 11	1.0335	86.93	13.07	9.10	.51	.42	.047	3.97	5.09
Feb. 8	1.0340	86.94	13.07	9.27	.54	.44	.046	3.80	4.72
Mar. 7	1.0337	86.87	13.16	9.32	.55	.45	.045	3.84	4.55
Apr. 4	1.0339	87.03	12.97	9.06	.55	.44	.045	3.92	5.09
May 2	1.0333	86.98	13.02	9.04	.55	.45	.042	3.98	5.29
May 30	1.0335	87.07	12.93	9.04	.57	.45	.042	3.90	4.73
June 27	1.0332	86.20	13.81	9.14	.63	.53	.055	4.67	4.61
July 18	1.0326	86.06	13.94	9.52	.70	.56	.029	4.42	4.31

COW NO. 403.

1908.									
Mar. 14	1.0348	87.15	12.85	9.27	0.52	0.42	0.053	3.58	5.21
Apr. 11	1.0328	87.85	12.16	8.78	.49	.38	.051	3.38	5.22
May 9	1.0327	88.25	11.75	8.57	.47	.36	.043	3.18	5.39
June 6	1.0317	88.44	11.56	8.40	.47	.37	.044	3.16	5.00
July 4	1.0315	88.44	11.56	8.42	.49	.37	.045	3.14	4.58
Aug. 1	1.0313	88.36	11.65	8.52	.51	.43	.033	3.13	5.16
Aug. 29	1.0321	87.23	12.77	9.54	.53	.46	.030	3.23	4.98
Sept. 26	1.0333	87.48	12.52	8.97	.57	.47	.045	3.55	5.11
Oct. 24	1.0334	87.62	12.38	8.54	.58	.46	.067	3.85	4.08
Nov. 21	1.0321	87.10	12.90	8.90	.60	.45	.093	4.00	4.17
Dec. 19	1.0327	86.81	13.19	9.15	.64	.48	.092	4.05	4.47

TABLE 5.—*Average analysis of the milk of each cow, by 4-week periods*—Continued.

Four weeks ending—	Ash.[1]	Relative size of globules.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.
COW NO. 4.							
1906.	*Per cent.*						*° C.*
Dec. 22	....	363	29.22	31.08	231.1	1.4601	32.36
1907.							
Jan. 19	....	423	28.72	28.04	233.1	1.4595	32.63
Feb. 16	....	370	28.52	29.61	232.9	....	33.39
Mar. 16	....	229	28.50	29.94	229.1	1.4594	33.25
Apr. 13	....	267	28.96	28.84	230.7	1.4593	33.30
May 11	....	235	29.20	28.03	229.0	1.4592	33.44
June 8	....	299	26.87	31.46	227.8	1.4589	32.94
July 6	....	318	28.63	29.75	229.4	1.4594	33.24
Aug. 3	....	228	25.24	32.27	234.4	....	33.03
Sept. 7[2]	....	167	25.95	32.15	235.9	1.4584	32.97
COW NO. 99.							
1907.							
Feb. 2	....	556	30.16	32.68	230.6	1.4601	24.94
Mar. 2	....	339	28.88	29.46	232.1	1.4597	33.24
Mar. 30	....	325	32.09	28.96	229.5	1.4592	33.36
Apr. 27	....	274	30.95	26.75	232.3	1.4589	34.53
May 25	....	264	27.67	29.99	227.7	....	33.78
June 22	....	349	31.21	27.29	231.7	1.4590	34.08
July 20	0.65	370	27.03	27.93	227.3	....	34.07
Aug. 17	.64	367	27.34	27.37	239.8	1.4580	34.33
Sept. 14	.65	270	27.03	28.71	234.3	....	34.64
Oct. 12	.76	209	25.83	28.80	231.4	1.4558	33.81
Nov. 9	.81	263	24.73	27.61	229.4	1.4564	34.88
Nov. 30	.91	315	18.43	29.55	219.6	1.4567	34.35
COW NO. 118.							
1906.							
Nov. 3	....	....	29.54	39.31	228.5	....	26.62
Dec. 1	....	....	23.28	36.33	224.7	....	32.66
Dec. 29	....	417	24.14	32.54	229.6	1.4604	33.31
1907.							
Jan. 26	....	879	23.69	28.69	229.0	1.4602	33.31
Feb. 23	....	358	23.90	31.55	230.2	1.4600	33.80
Mar. 23	....	373	24.64	30.43	226.6	1.4596	33.40
Apr. 20	....	301	26.66	28.67	229.4	1.4596	33.92
May 18	....	334	23.12	32.49	224.8	1.4602	33.66
June 15	....	335	25.04	33.67	225.1	1.4601	33.39
July 13	0.64	259	22.85	31.43	227.6	....	33.59
Aug. 10	.69	342	22.79	31.14	237.0	1.4578	33.81
Sept. 7	.76	229	20.22	32.47	223.9	1.4592	33.68
Oct. 5	.85	438	14.23	38.48	219.5	1.4570	33.46
Oct. 26[1]	....	461	14.21	35.82	219.1	1.4579	33.50
COW NO. 205.							
1907.							
Aug. 17	0.64	242	26.66	37.12	242.2	1.4598	33.41
Sept. 14	.61	147	26.01	34.54	229.3	....	32.67
Oct. 12	.64	148	26.33	33.23	229.0	1.4559	33.39
Nov. 9	.69	147	27.38	31.85	232.9	....	33.76
Dec. 7	.69	127	27.82	31.77	230.8	1.4568	33.02
1908.							
Jan. 4	.66	82	26.92	32.64	228.7	1.4571	32.93
Feb. 1	.59	107	28.05	32.62	228.1	1.4564	32.88
Feb. 29	.63	96	27.53	33.45	227.0	1.4566	32.98
Mar. 28	.62	98	27.86	34.07	225.0	....	33.26
Apr. 25	.62	90	26.06	35.55	223.9	....	33.09
May 23	.63	81	25.63	35.40	226.3	....	33.01
June 20	.65	117	20.39	37.53	220.8	....	32.54
July 18	....	102	12.77	42.57	210.1	....	41.80
Aug. 8	.70	179	10.27	42.24	205.9	....	48.34

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[1] Ash not determined for cow No. 4.

[2] Last period, 5 weeks.

TABLE 5.—*Average analysis of the milk of each cow, by 4-week periods*—Continued.

COW NO. 206.

Four weeks ending—	Ash.	Relative size of globules.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.
1907.	*Per cent.*						*° C.*
June 29		253	30.15	31.00	230.7		32.95
July 27	0.62	269	29.48	30.57	228.3		33.52
Aug. 24	.64	124	28.15	35.53	242.4	1.4584	31.94
Sept. 21	.71	157	24.58	31.70	233.7	1.4559	32.06
Oct. 19	.66	134	27.19	31.79	232.4	1.4565	32.47
Nov. 16		155	24.51	31.67	231.2		32.47
Dec. 14	.67	132	24.28	33.14	229.7	1.4569	32.64
1908.							
Jan. 11	.67	110	23.39	34.25	225.6	1.4576	33.13
Feb. 8	.67	96	23.53	33.91	224.4	1.4573	32.81
Mar. 7	.83	74	20.76	35.27	219.9	1.4575	32.92
Apr. 4	.86	79	17.62	36.53	216.4		38.80
COW No. 209.							
1907.							
Aug. 17	0.72	321	25.65	39.46	237.2	1.4598	32.58
Sept. 14	.69	139	26.84	33.32	230.6		32.16
Oct. 12	.66	136	25.10	32.89	231.6	1.4565	32.06
Nov. 9	.71	138	27.05	33.10	230.8		31.84
Dec. 7	.75	104	24.82	33.53	228.3	1.4576	33.04
1908.							
Jan. 4	.64	89	24.68	34.91	229.0	1.4578	31.69
Feb. 1	.67	98	22.79	36.62	224.0	1.4574	32.30
Feb. 29	.70	99	23.47	35.59	222.4	1.4570	32.78
Mar. 28	.71	105	24.23	37.01	222.0		32.85
Apr. 25	.74	79	20.17	39.08	219.2		33.82
May 23	.66	63	21.32	35.35	222.0		33.15
June 22	.68	76	20.70	36.69	220.3		35.45
July 4[1]	.76	118	21.14	39.03	215.3		37.39
COW No. 300.							
1908.							
Jan. 25	0.66	235	27.66	32.58	232.6	1.4569	34.80
Feb. 22	.67	163	28.96	28.70	230.7	1.4554	33.39
Mar. 21	.67	148	27.76	27.69	232.3		33.45
Apr. 18	.68	135	25.76	31.91	224.8		33.54
May 16	.66	115	26.83	27.50	229.2		33.74
June 13	.62	133	25.76	29.61	230.1		33.87
July 11	.68	93	24.57	35.30	224.5		33.83
Aug. 8	.61	80	23.87	37.32	222.0		33.30
Sept. 5	.57	75	23.09	35.23	223.9		33.30
Oct. 3		129	17.96	37.74	217.2		34.04
COW NO. 301.							
1907.							
Oct. 26	0.64	232	30.59	28.58	236.9	1.4564	32.07
Nov. 23	.66	189	27.09	29.91	234.1	1.4567	33.21
Dec. 21	.67	142	26.58	30.56	232.0	1.4569	32.61
1908.							
Jan. 18	.59	155	25.13	29.85	230.4	1.4563	32.80
Feb. 15	.60	165	24.88	30.93	227.5	1.4563	33.85
Mar. 14	.64	178	26.79	30.31	229.7		32.98
Apr. 11	.62	163	25.59	31.04	219.6		33.98
May 9	.55	151	26.40	30.54	228.3		33.55
June 6		146	24.42	32.64	228.4		33.33
July 4	.60	114	24.36	35.11	224.3		33.10
Aug. 1	.51	146	18.09	44.11	216.2		34.35
Aug. 29	.55	93	21.72	39.62	218.7		33.23
Sept. 19	.70	110	20.67	36.80	221.3		33.28

TABLE 5.—*Average analysis of the milk of each cow, by 4-week periods*—Continued.

COW NO. 400.

Four weeks ending—	Ash.	Relative size of globules.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.
1907.	*Per cent.*						° *C.*
Nov. 2	0.70	442	30.77	30.13	232.3	....	33.91
Nov. 30	.72	593	29.31	32.12	231.7	1.4570	32.99
Dec. 28	.69	317	25.95	39.05	224.2	1.4581	31.61
1908.							
Jan. 25	.67	245	25.99	31.36	230.0	1.4563	33.15
Feb. 22	.67	250	28.58	31.66	229.4	1.4557	33.01
Mar. 21	.75	277	26.54	33.31	227.2	....	33.88
Apr. 18	.72	231	24.70	35.71	223.9	....	33.63
May 16	.70	197	25.99	33.25	226.5	....	34.13
June 13	....	214	24.46	34.28	224.9	....	34.21
July 11	.79	179	22.57	36.91	220.5	....	36.40
Aug. 1	.85	194	22.25	38.49	216.8	....	36.49

COW NO. 402.

Four weeks ending—	Ash.	Relative size of globules.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.
1907.							
Nov. 16	0.71	566	30.72	30.76	234.3	....	32.69
Dec. 14	.72	561	27.14	29.21	233.9	1.4566	32.79
1908.							
Jan. 11	.70	394	26.69	31.15	229.8	1.4560	33.20
Feb. 8	.71	274	25.60	30.42	223.0	1.4560	33.09
Mar. 7	.72	280	26.07	32.08	228.3	....	32.95
Apr. 4	.72	232	24.12	35.16	224.3	....	33.99
May 2	.74	271	23.75	35.13	223.7	....	33.76
May 30	.72	214	22.93	35.47	222.7	....	33.79
June 27	.69	213	18.39	41.01	215.8	....	34.65
July 18	.86	193	16.61	42.19	211.5	....	36.31

COW NO. 403.

Four weeks ending—	Ash.	Relative size of globules.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.
1908.							
Mar. 14	....	357	29.36	33.33	234.3	....	32.70
Apr. 11	0.67	303	26.67	35.18	225.4	....	33.32
May 9	.71	213	26.31	33.19	228.1	....	32.70
June 6	.66	183	26.30	33.75	229.9	....	32.60
July 4	.61	134	25.69	35.28	226.4	....	33.15
Aug. 1	.57	141	26.02	35.57	230.1	....	32.98
Aug. 29	.69	146	26.38	34.96	224.6	....	32.54
Sept. 26	.69	147	24.53	36.34	225.1	....	32.65
Oct. 24	.69	203	23.27	37.32	223.8	....	33.14
Nov. 21	.76	175	24.25	35.24	226.4	....	33.28
Dec. 19	.87	128	25.51	35.04	226.6	....	32.83

TOTAL NITROGEN AND PROTEIN.

Table 6 gives the average per cent of total nitrogen in the milk of each of the 11 cows by 4-week periods. The figures for the individuals are also grouped by breeds in order that an average may be given representing each breed, and a grand average including all. The averages are also expressed in per cent of protein (N×6.38). The changes in the total protein for each cow by 4-week periods is represented in figures 1 to 11, and average for the 11 animals in figure 12.

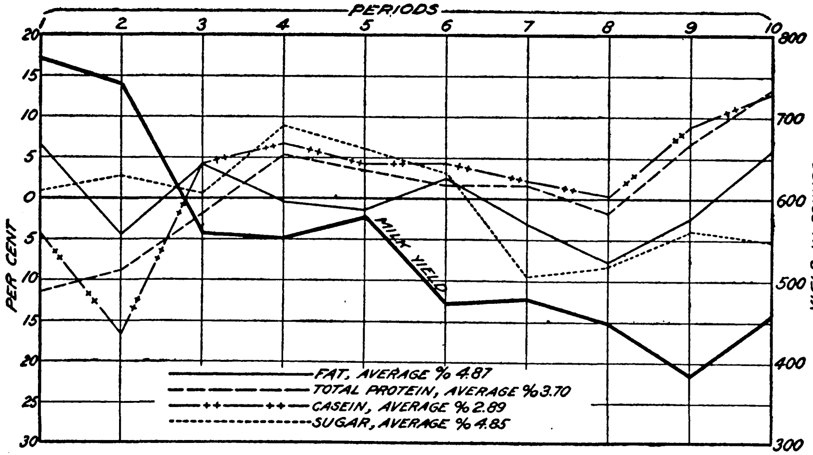

FIG. 1.—Diagram showing variation in yield and composition of milk of cow No. 4 at end of each 4-week period.

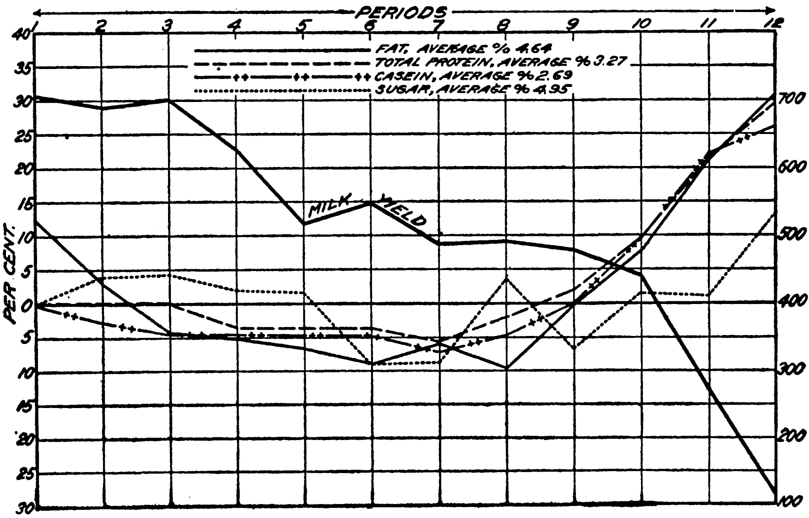

FIG. 2.—Diagram showing variation in yield and composition of milk of cow No. 99 at end of each 4-week period.

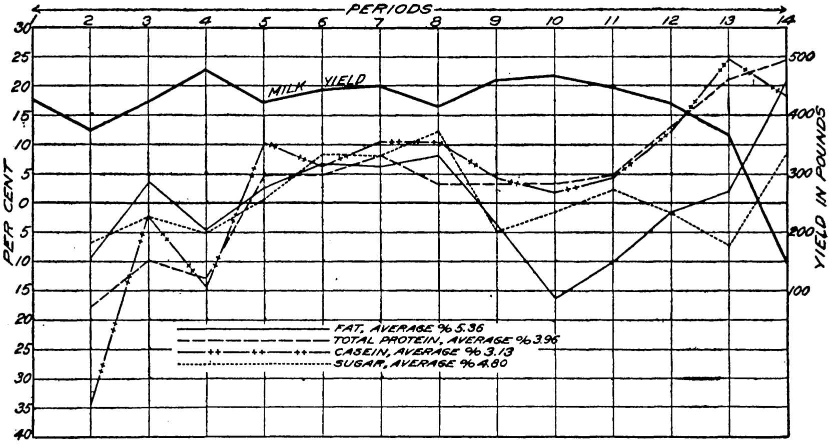

FIG. 3.—Diagram showing variation in yield and composition of milk of cow No. 118 at end of each 4-week period.

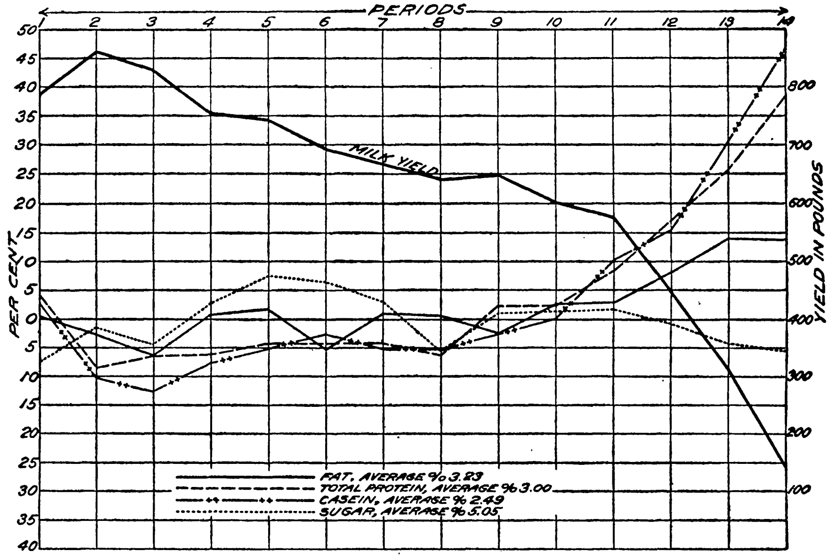

FIG. 4.—Diagram showing variation in yield and composition of milk of cow No. 205 at end of each 4-week period.

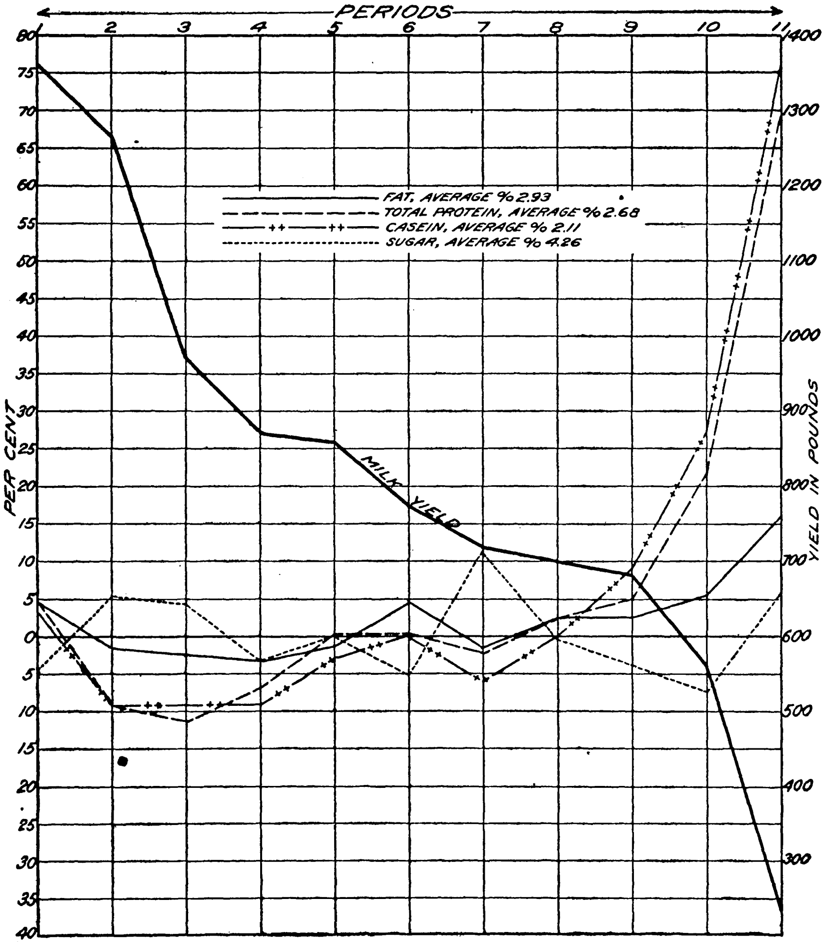

FIG. 5.—Diagram showing variation in yield and composition of milk of cow No. 206 at end of each 4-week period.

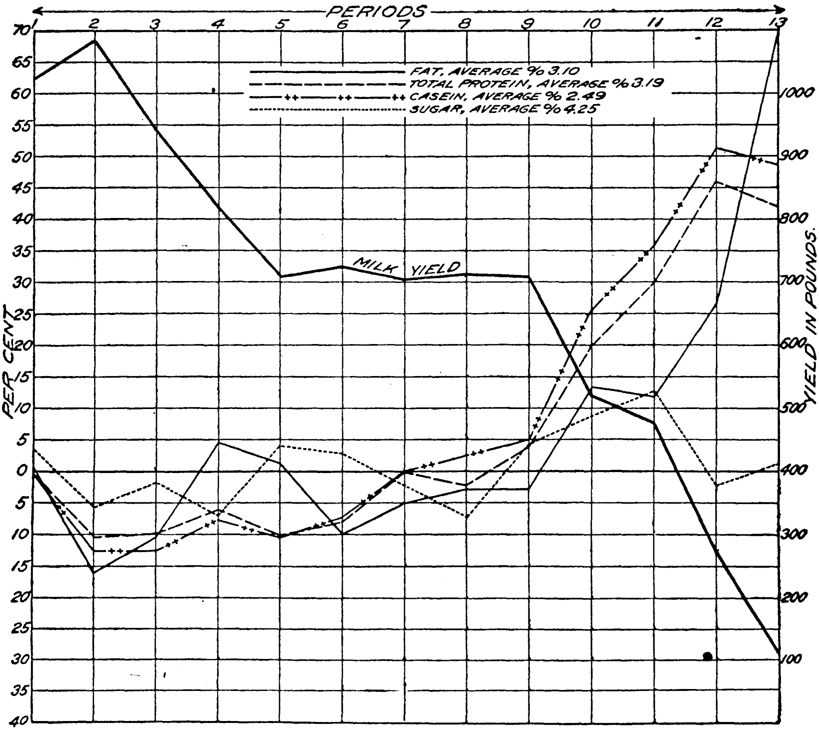

FIG. 6.—Diagram showing variation in yield and composition of milk of cow No. 209 at end of each 4-week period.

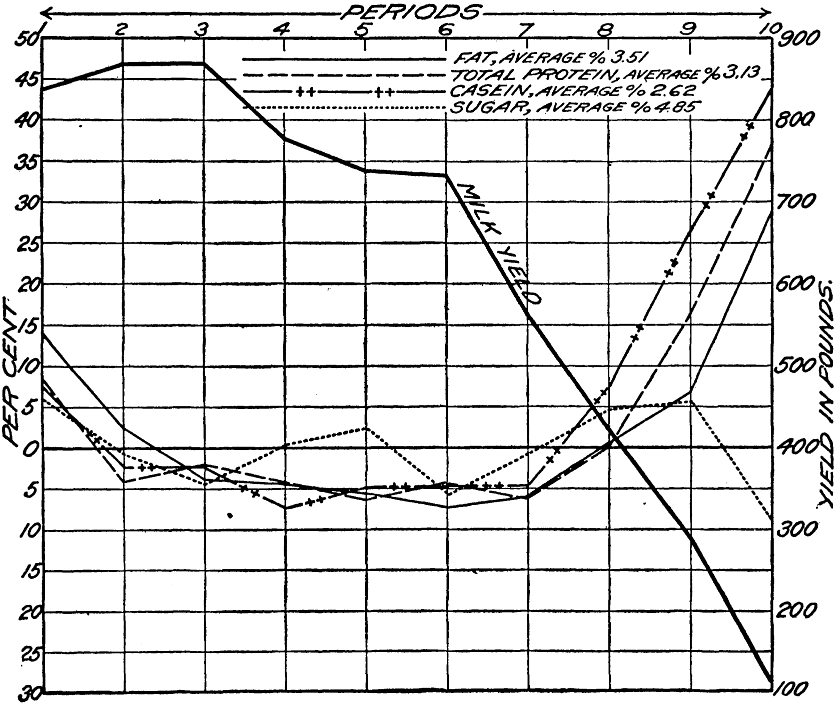

FIG. 7.—Diagram showing variation in yield and composition of milk of cow No. 300 at end of each 4-week period.

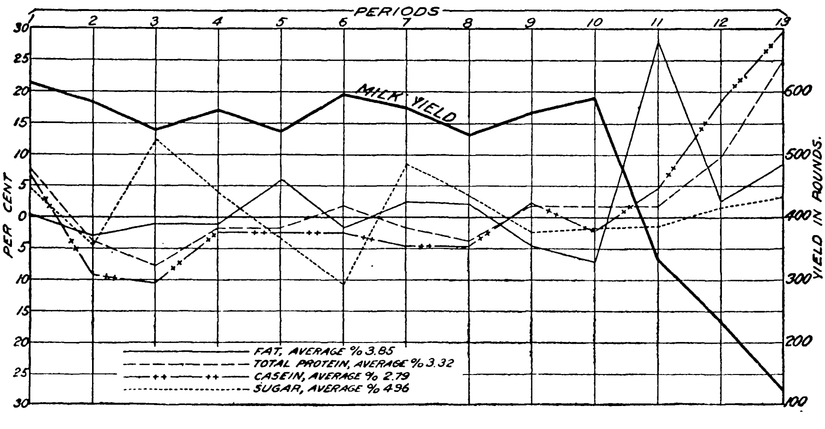

FIG. 8.—Diagram showing variation in yield and composition of milk of cow No. 301 at end of each 4-week period.

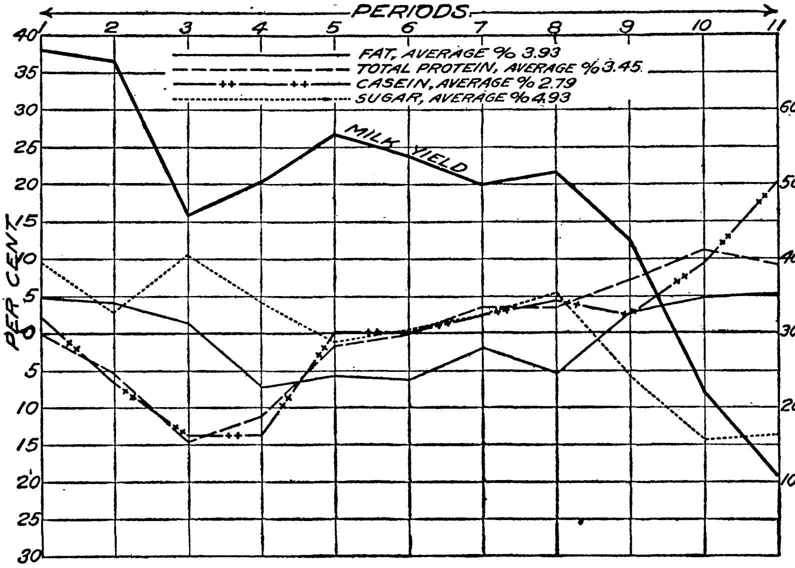

FIG. 9.—Diagram showing variation in yield and composition of milk of cow No. 400 at end of each 4-week period.

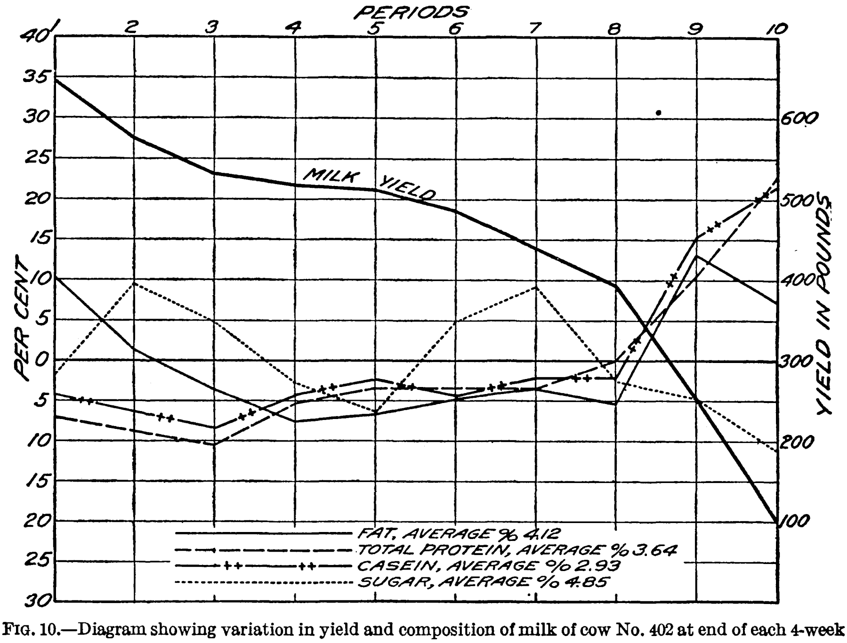

FIG. 10.—Diagram showing variation in yield and composition of milk of cow No. 402 at end of each 4-week period.

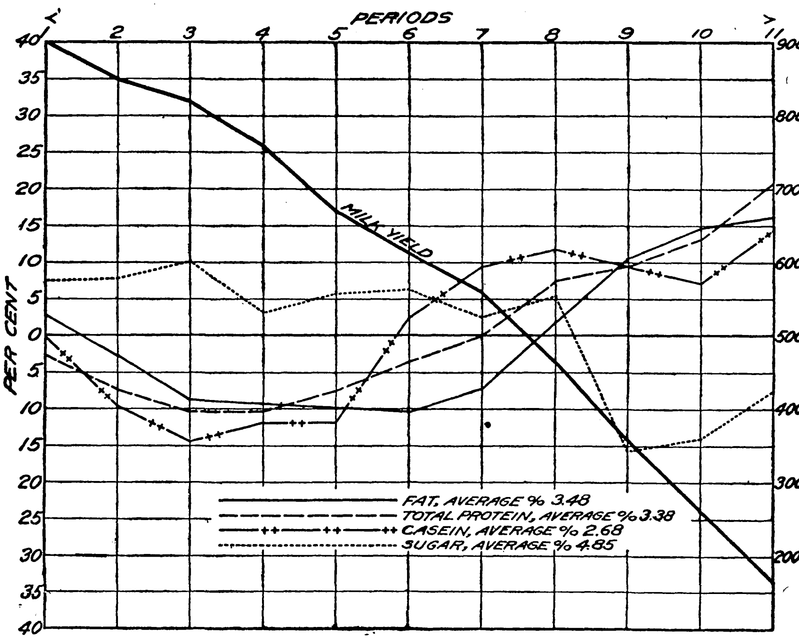

FIG. 11.—Diagram showing variation in yield and composition of milk of cow No. 403 at end of each 4-week period.

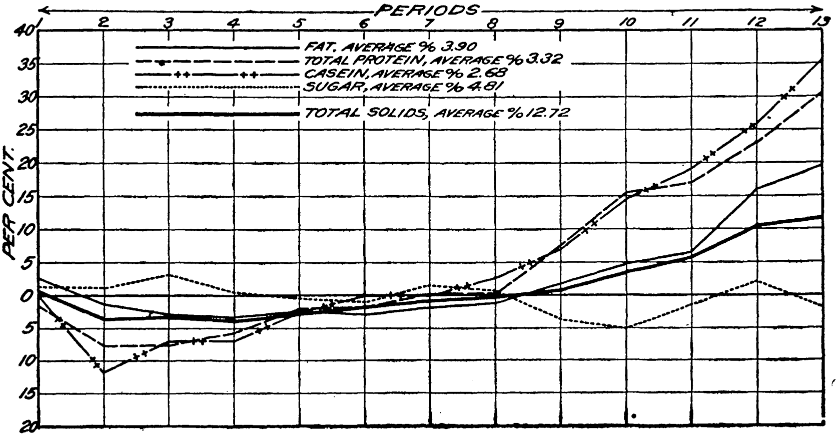

FIG. 12.—Diagram showing variation in yield and composition of milk at end of each 4-week period; average for 11 cows.

It is a well-established fact that the milk secreted immediately after parturition is abnormally high in albumin. But it is not generally understood that this is also true, although in lesser measure, of the other milk proteids, and that the normal per cent of this constituent is not reached for several weeks. The change in total nitrogen during the first 6 weeks is shown in Table 7. It must be borne in mind in studying this table that all analyses are made from what would be generally considered normal milk. In no case were the samples taken until the colostrum period was passed; therefore we can not ascribe the high total nitrogen content during the first few weeks to the high albumin content of the colostrum. It will be noted that in every case but one the per cent of nitrogen starts high, drops decidedly the second week, and reaches the lowest point in from 4 to 6 weeks.

After the lowest point is reached the per cent of total nitrogen remains fairly constant until about the eighth month of the lactation period, when it begins to rise gradually. Toward the end of the period it rises more rapidly until it attains its maximum at the end of the lactation period. The range of variation with individual cows and with the average is shown below.

	Low.	Average.	High.
Maximum range in per cent of total protein	2.36	2.68	4.53
Minimum range in per cent of total protein	3.32	3.70	4.21
Average (11 cows)	2.97	3.30	4.31

If we express the average total protein by 100 per cent the variation will be as follows:

	Low.	Average.	High.	Total range in per cent of average protein.
Maximum range	88.0	100	169.0	81.0
Minimum range	89.7	100	113.7	24.0
Average (11 cows)	90.0	100	130.6	40.6

The data show a wide range of variation in total protein during the normal lactation period. As compared with the fat, generally assumed to be the most valuable constituent, it will be found with the 11 cows used in this investigation that the variation in total protein exceeds the variation in fat. This is shown in figure 12. However, if the composition of the milk of each separate milking was known it is quite certain from other data at hand that the range of variation in the per cent of fat would be much greater than with the casein; that is to say, the fat varies more from milking to milking than does the total nitrogen; but eliminating these temporary variations the per cent of fat is less affected by the period of lactation than is the total nitrogen.

It might be mentioned at this point that the last samples included were still what would be considered as normal milk. In some instances analyses were made on samples taken up to the time that the cows ceased to produce milk, but these results are not included in the tables.

TABLE 6.—*Average total nitrogen for each cow and average total nitrogen and protein for each breed, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
4	0.52	0.53	0.57	0.61	0.60	0.59	0.59	0.57	0.62	0.66	.....	.....	.....	.....
99	.51	.51	.51	.49	.49	.49	.48	.50	.52	.56	0.62	0.66	.....	.....
118	.....	.51	.56	.54	.65	.65	.67	.64	.64	.64	.65	.70	0.75	0.77
Average total nitrogen for Jerseys	.52	.52	55	.55	.58	.58	.58	.57	.59	.62	.64	.68	.....	.....
Average total protein for Jerseys	3.32	3.32	3.51	3.51	3.70	3.70	3.70	3.64	3.76	3.96	4.08	4.34	.....	.....
205	.49	.43	.44	.44	.45	.45	.45	.44	.48	.48	.51	.55	.59	.65
206	.44	.38	.37	.39	.42	.42	.41	.43	.44	.51	.71	.....	.....	.....
209	.50	.45	.45	.47	.45	.46	.50	.49	.52	.60	.65	.73	.71	.....
Average total nitrogen for Holsteins	.48	.42	.42	.43	.44	.44	.45	.45	.48	.53	.62	.64	.65	.....
Average total protein for Holsteins	3.06	2.68	2.68	2.74	2.81	2.81	2.87	2.87	3.06	3.38	3.96	4.08	4.15	.....
300	.53	.47	.48	.47	.46	.47	.46	.48	.57	.67	.....	.....	.....	.....
301	.56	.50	.48	.51	.51	.53	.51	.50	.53	.53	.53	.57	.65	.....
Average total nitrogen for Ayrshires	.55	.49	.48	.49	.49	.50	.49	.50	.55	.60	.....	.....	.....	.....
Average total protein for Ayrshires	3.51	3.13	3.06	3.13	3.13	3.19	3.13	3.19	3.51	3.83	.....	.....	.....	.....
400	.54	.51	.46	.48	.53	.54	.56	.56	.58	.60	.59	.....	.....	.....
402	.53	.52	.51	.54	.55	.55	.55	.57	.63	.70	.....	.....	.....	.....
403	.52	.49	.47	.47	.49	.51	.53	.57	.58	.60	.64	.....	.....	.....
Average total nitrogen for Shorthorns	.53	.51	.48	.50	.52	.53	.55	.57	.60	.63	.62	.....	.....	.....
Average total protein for Shorthorns	3.38	3.25	3.06	3.19	3.32	3.38	3.51	3.64	3.83	4.02	3.96	.....	.....	.....
Grand average total nitrogen	.51	.48	.48	.49	.51	.51	.52	.52	.56	.60	.61	.64	.68	.64
Grand average total protein	3.25	3.06	3.06	3.13	3.25	3.25	3.32	3.32	3.57	3.83	3.89	4.08	4.34	.....
Variation in percentage of total protein, on basis of first period being 100 per cent	100	94	94	96	100	100	102	102	110	118	120	125	133	.....

TABLE 7.—*Showing change in the total nitrogen of each cow during the first 6 weeks.*

Week.	Cow No. 4.	Cow No. 99.	Cow No. 205.	Cow No. 206.	Cow No. 209.	Cow No. 300.	Cow No. 301.	Cow No. 400.	Cow No. 402.	Cow No. 403.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	0.52	0.55	0.54	0.53	0.61	0.61	0.64	0.57	0.58	0.57
2	.52	.52	.51	.43	.49	.53	.57	.54	.51	.51
3	....	.51	.46	.40	.44	.50	.54	.53	.51	.51
4	....	.46	.46	.39	.45	.48	.50	.53	.52	.50
5	.57	.51	.44	.37	.45	.46	.49	.51	.50	.51
6	.49	.52	.43	.38	.43	.46	.50	.52	.52	.48

It is believed this change in the per cent of total nitrogen during the lactation period, as shown by the data given, is entirely normal. Every cow, with one exception, showed a decline during the first few weeks, and all showed a rise in the latter end of the period, although with some this was much more marked than with others.

The authors suggest that this normal decline in total protein in the early part of the lactation period is due to the physical condition of the animal. Under normal conditions a cow is in a good physical condition at calving time. That is to say, she has been on a high plane of nutrition and has stored surplus fat and protein in the body. This is a provision of nature to prepare the animal to produce milk for her young, if necessary partly at the expense of her own body.

After calving, under normal conditions, the cow loses in weight for from 2 to 10 weeks. This means that she does not consume sufficient food to furnish maintenance and support the milk production. Consequently, she draws for some time on her stored nutrients and loses weight. This loss of weight happened with the 11 cows used in the investigation here reported. Perhaps on the average the decline in weight was rather more than the normal. Unfortunately, no complete records of weight were kept.

However, by referring to Tables 27 and 28 data may be studied that bear directly upon this problem. The 5 cows dealt with in these tables were used in another investigation in which it was an important part of the plan to maintain a uniform weight throughout the milking period. The weights given are the averages of daily weight for the period included. It will be observed that except in the case of No. 27 practically uniform weights were maintained. No. 27, on account of the large amount of milk produced and because she suffered from some indigestion, lost weight rapidly during the first 10 days. The total nitrogen in her milk was also low at this stage and, in fact, follows her decrease and increase in weight in general throughout the milking period. The other 4 cows were maintained at practically the same weight throughout the entire milking period, and it will be observed that the per cent of total nitrogen is almost constant. It should be understood that these cows were farrow, which may account for the fact that there was no marked increase in the total nitrogen in the last part of the lactation period, but it does not account for the fact that there was no decline in the first few weeks.

CASEIN NITROGEN AND CASEIN.

Table 8 gives the casein nitrogen by 4-week periods for each cow, with an average for each breed and for the 11 cows. The averages are also expressed in casein found by using the factor 6.38.

The variations in the casein nitrogen during the lactation period are similar to those of the total nitrogen. There is the same decline during the first few weeks, followed by a gradual rise lasting from 5 to 8 months, then a more rapid increase to the end of the period.

The range of variations in casein content with individual cows and with the average is shown below:

	Low.	Average.	High.
Maximum range in per cent casein	2.04	3.14	3.89
Minimum range in per cent casein	2.30	2.61	3.06
Average (11 cows)	2.32	2.68	3.56

If we express the average casein content by 100 per cent, the maximum and minimum would be as follows:

	Low.	Average.	High.	Total range in per cent of average casein.
Maximum range	64.9	100	123.8	58.9
Minimum range	88.1	100	117.2	29.0
Average (11 cows)	86.5	100	130.0	45.5

The maximum range of variation is 1.85 per cent of casein, or 58.9 per cent of the average casein content; the minimum is 29.1 per cent of the average; while the 11 cows show an average variation of 1.21 per cent, or 45.5 of the average casein content. It will be noted that the maximum range is caused by one exceptionally low figure, while the high point reached by the same animal is closer to her average than is the case with the average figures for the 11 cows.

It will be further noted that with the average figures the minimum figure is only 0.36 per cent below the mean, while the maximum is 0.88 above. The greater variation in the latter is due to the exceedingly high figures reached at the end of the lactation period.

TABLE 8.—*Average casein nitrogen for each cow, and breed average, and average casein nitrogen and casein for each breed, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4	0.44	0.38	0.48	0.49	0.48	0.47	0.47	0.46	0.50	0.52	.....	.....	.....	.....
99	.42	.41	.40	.40	.40	.40	.39	.40	.42	.46	0.51	0.53	.....	.....
118	.....	.32	.48	.42	.54	.52	.54	.54	.51	.50	.51	.55	0.61	0.58
Average casein nitrogen for Jerseys	.43	.37	.45	.44	.47	.47	.47	.47	.48	.49	.51	.54	.....	.....
Average casein for Jerseys	2.74	2.36	2.87	2.81	3.00	3.00	3.00	3.00	3.06	3.13	3.25	3.45	.....	.....
205	.40	.35	.34	.36	.37	.38	.37	.37	.38	.39	.43	.45	.51	.57
206	.34	.30	.29	.30	.32	.33	.31	.33	.36	.42	.58	.....	.....	.....
209	.39	.34	.34	.36	.35	.36	.39	.40	.41	.49	.53	.59	.58	.....
Average casein nitrogen for Holsteins	.38	.33	.32	.34	.35	.36	.36	.37	.38	.43	.51	.52	.55	.....
Average casein for Holsteins	2.42	2.11	2.04	2.17	2.23	2.30	2.30	2.36	2.42	2.74	3.25	3.32	3.51	.....
300	.44	.40	.40	.38	.39	.39	.39	.44	.52	.59	.....	.....	.....	.....
301	.47	.40	.39	.43	.43	.43	.42	.42	.45	.43	.46	.52	.57	.....
Average casein nitrogen for Ayrshires	.46	.40	.40	.41	.41	.41	.41	.43	.49	.51	.....	.....	.....	.....
Average casein for Ayrshires	2.93	2.55	2.55	2.62	2.62	2.62	2.62	2.74	3.13	3.25	.....	.....	.....	.....
400	.45	.41	.38	.38	.44	.44	.45	.46	.45	.48	.53	.....	.....	.....
402	.44	.43	.42	.44	.45	.44	.45	.45	.53	.56	.....	.....	.....	.....
403	.42	.38	.36	.37	.37	.43	.46	.47	.46	.45	.48	.....	.....	.....
Average casein nitrogen for Shorthorns	.44	.41	.39	.40	.42	.44	.45	.46	.48	.50	.51	.....	.....	.....
Average casein for Shorthorns	2.81	2.62	2.49	2.55	2.68	2.81	2.87	2.93	3.06	3.19	3.25	.....	.....	.....
Grand average casein nitrogen	.42	.37	.39	.39	.41	.42	.42	.43	.45	.48	.50	.53	.57	.58
Grand average casein	2.68	2.36	2.49	2.49	2.62	2.68	2.68	2.74	2.87	3.06	3.19	3.38	3.64	3.70
Variation in percentage of casein on basis of first period being 100 per cent	100	88	93	93	98	100	100	102	107	114	119	126	136	138

Table 9 gives the ratio of casein nitrogen to total nitrogen for each animal. A striking uniformity will be observed in this table. From 79 to 83 per cent of the total nitrogen consists of casein in most cases. This ratio shows but little change even when the total protein makes a wide variation.

Table 10 shows this relation by weeks for the first 5 and the last 5 weeks of the lactation period. The milk at these two extremes of the milking period shows the widest variation in composition, but it will be noted the ratio between the total nitrogen and the casein remains practically unaffected. For example, cow No. 206 in the third period averaged 0.29 per cent total nitrogen, of which 78 per cent was casein. In her eleventh period she averaged 0.58 per cent total nitrogen, or exactly double that of the third period, of which 82 per cent was casein. There seems to be only a slight effect that can be attributed to the advance in the period of lactation, and that is a small increase in the relative amount of casein in the last part of the lactation period, when the per cent of total protein increases very rapidly.

TABLE 9.—*Average ratio of casein nitrogen to total nitrogen, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4	0.85	0.72	0.84	0.80	0.80	0.81	0.80	0.81	0.81	0.79	.....	.....	.....	.....
99	.82	.80	.78	.82	.82	.82	.81	.80	.81	.82	0.82	0.80	.....	.....
118	.....	.63	.86	.78	.83	.80	.81	.84	.80	.78	.79	.79	0.81	0.75
Average for Jerseys	.84	.72	.83	.80	.82	.81	.81	.82	.81	.80	.81	.80	.81	.75
205	.82	.81	.77	.82	.82	.84	.82	.84	.79	.81	.84	.82	.86	.88
206	.77	.79	.78	.77	.76	.79	.76	.77	.82	.82	.82	.....	.....	.....
209	.78	.76	.76	.77	.78	.78	.78	.82	.79	.82	.82	.81	.82	.....
Average for Holsteins	.79	.79	.77	.79	.79	.80	.79	.81	.80	.82	.83	.82	.84	.88
300	.83	.85	.83	.81	.85	.83	.85	.90	.91	.88	.....	.....	.....	.....
301	.84	.80	.81	.84	.84	.81	.82	.84	.85	.81	.87	.91	.88	.....
Average for Ayrshires	.84	.83	.82	.83	.85	.82	.84	.87	.88	.85	.87	.91	.88	.....
400	.83	.80	.83	.79	.83	.82	.80	.82	.78	.80	.90	.....	.....	.....
402	.83	.83	.82	.82	.82	.80	.82	.79	.84	.80	.....	.....	.....	.....
403	.81	.78	.77	.79	.76	.84	.87	.83	.79	.75	.75	.....	.....	.....
Average for Shorthorns	.82	.80	.81	.80	.80	.82	.83	.81	.80	.78	.83	.....	.....	.....
Grand total average	.82	.78	.80	.80	.81	.81	.81	.82	.82	.81	.83	.83	.84	.82

TABLE 10.—*Ratio of casein nitrogen to total nitrogen for each cow for first 5 and last 5 weeks of lactation period.*

Stage.	Cow No.—										
	4	99	118	205	206	209	300	301	400	402	403
First week	0.88	0.78	......	0.80	0.77	0.75	0.80	0.83	0.82	0.83	0.81
Second week	......	.85	......	.80	.79	.80	.83	.86	.83	.84	.84
Third week	......	.78	......	.83	.78	.77	.86	.85	.85	.82	.76
Fourth week	......	.91	......	.80	.77	.80	.83	.82	.79	.88	.76
Fifth week	......	.80	......	.80	.81	.76	.87	.84	.80	.84	.72
Fifth week from end	.79	.75	0.79	.82	.79	.79	.91	.95	.82	.81	.73
Fourth week from end	.80	.83	.78	.89	.80	.85	.90	.90	.84	.86	.75
Third week from end	.76	.83	.81	.90	.79	.78	.89	.92	.90	.59	.73
Second week from end	.78	.78	.71	.89	.85	.84	.86	.85	.86	.89	.74
Last week	.79	.79	.75	.85	.79	.79	.85	.87	.93	.92	.77

ALBUMIN.

Table 11 shows the amount of nitrogen as albumin. The average for the breeds and the grand average is also expressed as albumin by using the factor 6.38. The nitrogen as albumin was determined as already stated by the provisional method of coagulating the filtrate from the casein-nitrogen determination by heat and finding the amount of nitrogen in the residue by the Gunning method. This method has proved unsatisfactory, failing to yield concordant results even when the greatest of care is used in carrying it out. This is no doubt due to the similarity of the albumin and the remaining soluble proteins. It is impossible with the provisional method to separate the albumin from the remaining protein with any degree of accuracy. This probably accounts for some of the extreme variations found in the results here reported.

TABLE 11.—*Average albumin nitrogen and albumin, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4	0.059	0.056	0.057	0.067	0.045	0.031	0.064	0.061	0.062	0.063	.....	.....	.....	.....
99	.038	.054	.037	.025	.029	.043	.036	.041	.035	.043	0.042	0.071	.....	.....
118	.....	.081	.051	.057	.074	.071	.049	.057	.062	.069	.062	.065	0.061	0.062
Average albumin nitrogen for Jerseys	.049	.064	.048	.050	.049	.048	.050	.053	.053	.058	.052	.068	.....	.....
Average albumin for Jerseys	.313	.408	.306	.319	.313	.306	.319	.338	.338	.370	.332	.434	.....	.....
205	.041	.032	.031	.032	.034	.032	.037	.036	.027	.032	.035	.038	.025	.027
206	.042	.028	.030	.022	.028	.034	.040	.036	.036	.039	.065	.....	.....	.....
209	.051	.032	.037	.038	.034	.042	.044	.047	.038	.057	.063	.084	.067	.....
Average albumin nitrogen for Holsteins	.045	.031	.033	.031	.032	.036	.040	.040	.034	.043	.054	.041	.031	.....
Average albumin for Holsteins	.287	.198	.211	.198	.204	.230	.255	.255	.217	.274	.345	.262	.198	.....
300	.039	.031	.027	.030	.031	.029	.029	.019	.017	.032	.....	.....	.....	.....
301	.043	.032	.042	.035	.042	.046	.043	.036	.033	.036	.033	.024	.032	.....
Average albumin nitrogen for Ayrshires	.041	.032	.035	.033	.037	.038	.036	.028	.025	.034	.....	.....	.....	.....
Average albumin for Ayrshires	.262	.204	.223	.211	.236	.242	.230	.179	.160	.217	.....	.....	.....	.....
400	.055	.053	.033	.043	.045	.043	.057	.046	.046	.038	.027	.....	.....	.....
402	.051	.049	.047	.046	.045	.045	.042	.042	.055	.029	.....	.....	.....	.....
403	.053	.051	.043	.044	.045	.033	.030	.045	.067	.093	.092	.....	.....	.....
Average albumin nitrogen for Shorthorns	.053	.051	.041	.044	.045	.040	.043	.044	.056	.053	.060	.....	.....	.....
Average albumin for Shorthorns	.338	.325	.262	.281	.287	.255	.274	.281	.357	.338	.383	.....	.....	.....
Grand average albumin nitrogen	.047	.045	.040	.040	.041	.042	.043	.042	.044	.048	.052	.056	.046	.045
Grand average albumin	.300	.287	.255	.255	.262	.268	.274	.268	.281	.306	.332	.357	.293	.287
Variation in percentage of albumin, on basis of first period being 100 per cent	100	95	85	85	87	89	91	89	93	102	111	119	97	96

Since the figures given in Table 11 are in each case the average of 4 samples each representing one week, the extreme variations which occur in the weekly tables given in the appendix and which it is recognized are due in part to the method used, are largely removed, and it is possible to study the general effect of the lactation period on the albumin nitrogen.

The albumin nitrogen follows the same course as the casein nitrogen during the lactation period. In the beginning it is higher than the average, soon declines, reaching the minimum about the third month.

From this point on there is a gradual rise, which becomes much more pronounced at the end. The range in albumin by individual animals in 4-week periods is as follows:

	Low.	Average.	High.
Maximum range in per cent albumin	0.191	0.310	0.593
Minimum range in per cent albumin	.159	.213	.262
Average (11 cows)	.181	.279	.405

If we express the average albumin by 100, the results given above would be as follows:

	Low.	Average.	High.	Total range in per cent average albumin.
Maximum range	61.6	100	191.2	130.0
Minimum range	74.6	100	123.0	48.4
Average range (11 cows)	64.8	100	145.1	80.3

Table 12 shows the ratio of albumin to total nitrogen. It will be observed that, like the casein nitrogen, the albumin nitrogen bears a definite relation to the total nitrogen. This table shows the albumin nitrogen to constitute on the average 8.1 per cent of the total, and the only variation in this ratio that can be attributed to the period of lactation is the somewhat smaller proportion of albumin in the last 3 or 4 week periods.

TABLE 12.—*Relation of the casein, albumin, and residual nitrogen to the total nitrogen, by 4-week periods.*

Period No.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Residual nitrogen.	Period No. No.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Residual nitrogen.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	100	82	9	9	9	100	82	8	10
2	100	78	9	13	10	100	81	8	11
3	100	80	8	12	11	100	83	9	8
4	100	80	8	12	12	100	83	9	8
5	100	81	8	11	13	100	84	7	9
6	100	81	8	11	14	100	82	6	12
7	100	81	8	11					
8	100	82	8	10	Average	100	81.4	8.1	11

THE RESIDUAL NITROGEN.

Under this term as here used is included the nitrogen remaining in solution after that precipitated as albumin is removed by filtering. The chemical nature of the nitrogen compounds included in this group will not be considered.

Below is given the average residual nitrogen for the 11 cows by 4-week periods:

	Period.											
	1	2	3	4	5	6	7	8	9	10	11	12
Per cent residual nitrogen..	0.046	0.062	0.053	0.058	0.055	0.056	0.054	0.050	0.058	0.066	0.056	0.058

It will be observed that this amount does not show any variation that can be ascribed to the period of lactation. The total amount is slightly more than that classed as albumin.

RATIO OF PROTEINS TO OTHER CONSTITUENTS.

Table 12 also gives a summary of the relation of the casein nitrogen, albumin nitrogen, and residual nitrogen to the total nitrogen. On the average 81.4 per cent of the total nitrogen is present as casein, and, as already pointed out, this ratio shows but little variation during the lactation period. The nitrogen determined as albumin varies from 7 to 9 per cent of the total and the residual nitrogen averages 11 per cent of the total.

Table 13 shows the relation between the total protein and the sugar. We find that the ratio of the sugar to the total protein increases during the first 10 or 12 weeks, reaching the maximum, as a rule, in the third month. From this period there is little change until the ninth month, when the ratio rapidly becomes narrower to the end of the period. This change is brought about by the fact that the per cent of sugar remains practically constant, while the total protein changes considerably during the lactation period. The data given indicate that the per cent of sugar does not follow the variation of the nitrogen and seems to bear no special relation to it. On the average there is found 1.45 pounds of sugar for each pound of protein.

TABLE 13.—*Average ratio of sugar to total protein, by 4-week periods.*

Period.	Total protein.	Sugar.				
		Average for 3 Jerseys.	Average for 3 Holsteins.	Average for 2 Ayrshires.	Average for 3 Shorthorns.	Average for 11 cows.
1......	1.00	1.50	1.44	1.47	1.52	1.47
2......	1.00	1.48	1.69	1.54	1.60	1.58
3......	1.00	1.41	1.69	1.68	1.74	1.62
4......	1.00	1.43	1.61	1.61	1.57	1.55
5......	1.00	1.37	1.67	1.58	1.40	1.50
6......	1.00	1.34	1.62	1.35	1.49	1.46
7......	1.00	1.29	1.64	1.65	1.46	1.50
8......	1.00	1.39	1.50	1.62	1.39	1.46
9......	1.00	1.23	1.49	1.42	1.17	1.32
10......	1.00	1.22	1.36	1.24	1.05	1.22
11......	1.00	1.22	1.24	1.45	1.11	1.23
12......	1.00	1.19	1.16	1.39	....	1.22
13......	1.00	....	1.13	....	....	1.13

FAT.

Table 14 gives the per cent of fat for each cow by 4-week periods, and the same is shown graphically in figures 1 to 11. Figure 12 indicates the average change in the per cent of fat for the 11 cows. An examination of the weekly tables in the appendix will show wide variations with individuals and at different periods. Leaving these minor variations out of consideration, the normal variation during the lactation period may be studied.

The data in the table show that there is a decline in fat during the first 3 months, followed by a period of from 4 to 5 months with little change. From this point on to the end of the lactation period the fat increases rapidly, reaching the maximum at the close. The results from practically every cow agree with this general statement. It is generally recognized that as a rule the milk becomes richer in fat toward the end of the lactation period, but an error is commonly made in assuming that this change is a gradual one from near the beginning of the milking period. On the contrary, there is little increase in the per cent of fat as a rule until that period is reached—ordinarily within 2 months of the end of the lactation period—when a rapid decline begins in the quantity of milk produced.

There are several factors that influence the per cent of fat in milk as consistently as does the stage of the lactation period, and these factors may even entirely overbalance the usual effect of advancing lactation. One of the authors has recently called attention to two factors that have such an influence. One of these is a variation that occurs with the season,[1] which tends, in this climate at least, to cause a low per cent of fat in the middle of the summer and a higher in early winter regardless of the date of the beginning of the lactation period. The other is the influence of the physical condition of the animal.[2] If the animal carries a large amount of body fat at calving time, her milk during the first few weeks, when the body weight is declining from the absorption of fat from the body, will contain more than the normal amount of fat for that particular animal. This latter is probably the explanation of the decline in fat observed in Table 14, which gives the results for the 11 cows used in this investigation.

There is in general some relation between the amount of milk and the per cent of fat. When there is a sudden decline in the amount of milk secreted for any reason, as, for example, during sickness or on account of the animal having been moved to strange surroundings, the per cent of fat with few exceptions increases sharply. The same holds true in the rapid decline that occurs in the last portion of the lactation period. When the decline in milk secreted is gradual, as is the case during the middle part of the lactation period, there is no special tendency for the per cent of fat to increase. However, while it is safe to make this general statement concerning the influence of the period of lactation when conditions are normal and when a sufficient number of animals are included to eliminate minor variations, it must be borne in mind that individual animals such as are found in commercial dairies may diverge widely from this general rule owing to other factors or combinations of factors which exert a greater influence.

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[1] Eckles, C. H. Jahreszeitliche Schwankungen des prozentischen Fettgehaltes in Kuhmilch. Milchwirtschaftliches Zentralblatt, vol. 5, No. 11, pp. 488–502. Leipzig, November, 1909.

[2] Eckles, C. H. The influence of the fatness of cow at parturition on per cent of fat in milk. Missouri Experiment Station Bulletin 100. Columbia, Mo., 1912.

TABLE 14.—*Average per cent of fat for each cow, and breed average, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
4	5.17	4.63	5.07	4.85	4.81	5.00	4.73	4.51	4.73	5.18	.....	.....	.....	.....
99	5.22	4.79	4.43	4.40	4.33	4.22	4.36	4.18	4.63	4.98	5.62	6.07	.....	.....
118	.....	5.31	5.55	5.11	5.51	5.71	5.69	5.80	5.17	4.47	4.83	5.28	5.48	6.47
Average for Jerseys	5.20	4.91	5.02	4.79	4.88	4.98	4.93	4.83	4.84	4.88	5.23	5.68	5.48	6.47
205	3.24	3.14	3.02	3.25	3.29	3.06	3.26	3.25	3.15	3.31	3.31	3.49	3.68	3.68
206	3.07	2.88	2.58	2.84	2.89	3.06	2.88	3.00	3.00	3.09	3.40	.....	.....	.....
209	3.12	2.60	2.74	3.24	3.14	2.81	2.94	3.01	3.01	3.52	3.46	3.90	5.28	.....
Average for Holsteins	3.14	2.87	2.78	3.11	3.11	2.98	3.03	3.09	3.05	3.31	3.39	3.70	4.48	3.68
300	4.01	3.61	3.38	3.36	3.32	3.26	3.30	3.53	3.74	4.52	.....	.....	.....	.....
301	3.87	3.74	3.81	3.81	4.08	3.78	3.95	3.94	3.67	3.58	4.92	3.96	4.18	.....
Average for Ayrshires	3.94	3.68	3.60	3.59	3.70	3.52	3.63	3.74	3.71	4.05	4.92	3.96	4.18	.....
400	4.12	4.09	3.99	3.65	3.70	3.69	3.85	3.73	4.05	4.16	4.17	.....	.....	.....
402	4.55	4.17	3.97	3.80	3.84	3.92	3.98	3.90	4.67	4.42	.....	.....	.....	.....
403	3.58	3.38	3.18	3.16	3.14	3.13	3.23	3.55	3.85	4.00	4.05	.....	.....	.....
Average for Shorthorns	4.08	3.88	3.71	3.54	3.56	3.58	3.69	3.73	4.19	4.19	4.11	.....	.....	.....
Grand total average	4.00	3.85	3.79	3.77	3.82	3.79	3.83	3.85	3.97	4.11	4.22	4.54	4.66	5.08

RELATION OF FAT TO OTHER CONSTITUENTS.

An examination of the data and the curves will show a similarity between the variation in the total protein and in the fat. While sudden variations in fat content from one milking to another are not accompanied by corresponding variations in the total protein, yet when the fat is permanently increased the protein is almost certain to be increased in the same proportion. While the ratio of fat to protein varies with individuals and breeds, it varies but little with the same individual from month to month.

Table 15 is a summary of the influence of the stage of lactation on the fat, and the relation of the fat to total protein and casein. It will be observed that this ratio is fairly uniform. As compared to the average the total protein, as well as the casein, is low in the beginning in proportion to the fat, and increases gradually until it reaches the maximum near the end of the lactation period. This results from the fact that the total protein increases more during the progress of the lactation period, especially during the last four months, than does the fat. On the average there is 0.86 pound of total protein and 0.71 pound of casein for each pound of fat. This relation is of interest in connection with the buying of milk for cheese making and the use of milk for food. Figure 12 shows that the total protein is influenced more by the stage of lactation than is the fat. Even at the end of the lactation period the per cent of fat on the average is only 20 per cent above the mean, while the total protein increases to 30 per cent above the mean.

TABLE 15.—*Relation of total protein and casein to fat, averaged by 4-week periods.*

Period.	Fat.	Total protein.	Casein.	Parts protein for 1 part fat.	Parts casein for 1 part fat.	Period.	Fat.	Total protein.	Casein.	Parts protein for 1 part fat.	Parts casein for 1 part fat.
	Per ct.	*Per ct.*	*Per ct.*				*Per ct.*	*Per ct.*	*Per ct.*		
1	4.00	3.25	2.68	0.81	0.67	9	3.97	3.57	2.87	0.90	0.72
2	3.85	3.06	2.36	.79	.61	10	4.11	3.83	3.06	.93	.74
3	3.79	3.06	2.49	.81	.66	11	4.22	3.89	3.19	.92	.76
4	3.77	3.13	2.49	.83	.66	12	4.54	4.08	3.38	.90	.74
5	3.82	3.25	2.62	.85	.69	13	4.66	4.34	3.64	.93	.78
6	3.79	3.25	2.68	.86	.71	14	5.08	4.08	3.70	.80	.73
7	3.83	3.32	2.68	.87	.70						
8	3.85	3.32	2.74	.86	.71	Average.	4.09	3.53	2.90	.86	.71

Table 16 shows the relation between the fat and the sugar as influenced by the stage of lactation. It will be observed that from the first period to the second and third there is some increase in the ratio. The columns giving the amount of sugar and fat, however, show that this is due not to an increase in the sugar but to a decrease in the fat.

The ratio remains practically the same from the second to the eighth period, after which it becomes considerably less, due to some decline in the amount of sugar and an increase in the per cent of fat.

TABLE 16.—*Relation of sugar to fat, averaged by 4-week periods.*

Period.	Fat.	Sugar.	Parts sugar for 1 part fat.	Period.	Fat.	Sugar.	Parts sugar for 1 part fat.
	Per cent.	*Per cent.*			*Per cent.*	*Per cent.*	
1	4.00	4.87	1.22	9	3.97	4.62	1.20
2	3.85	4.84	1.30	10	4.11	4.55	1.13
3	3.79	4.94	1.36	11	4.22	4.74	1.16
4	3.77	4.82	1.31	12	4.54	4.91	1.12
5	3.82	4.80	1.29	13	4.66	4.70	1.05
6	3.79	4.75	1.30	14	5.08	5.01	1.06
7	3.83	4.88	1.32				
8	3.85	4.83	1.28	Average	4.09	4.80	1.22

The ratio existing between the fat and the total protein is summarized in Table 17.

TABLE 17.—*Ratio of fat to total protein, averaged by 4-week periods.*

Period.	Total protein.	Fat.				
		Average for 3 Jerseys.	Average for 3 Holsteins.	Average for 2 Ayrshires.	Average for 3 Shorthorns.	Average for 11 cows.
1	1.00	1.58	1.04	1.14	1.21	1.22
2	1.00	1.49	1.08	1.19	1.20	1.24
3	1.00	1.44	1.04	1.17	1.21	1.22
4	1.00	1.38	1.13	1.15	1.12	1.20
5	1.00	1.32	1.11	1.19	1.06	1.17
6	1.00	1.35	1.05	1.10	1.05	1.14
7	1.00	1.34	1.05	1.17	1.06	1.15
8	1.00	1.32	1.07	1.18	1.03	1.15
9	1.00	1.29	1.00	1.06	1.10	1.12
10	1.00	1.24	.984	1.06	1.04	1.08
11	1.00	1.29	.867	....	1.05	1.09
12	1.00	1.31	.917	....	....	1.11
13	1.00	....	1.07	....	....	1.07
14	1.00	....	....	....	....	....

SUGAR.

Table 18 gives the per cent of sugar by 4-week periods for each cow, also an average by breeds and for the 11 cows. The curves in figures 1 to 11 show the changes in the per cent of sugar for each animal individually, and figure 12 illustrates the average for all the cows. The statements made by various authorities that the sugar is the least variable of the milk constituents except the ash seems to be borne out by the data here presented. The per cent of sugar is strikingly uniform as compared with the protein and fat. The only change that can be observed that seems to be brought about by the stage of lactation is a slight decline during the last 3 or 4 months of the period. This decline is marked with some individuals, while others are uniform or even increase slightly. The general average as well as that for most of the individuals shows a slight decline, which seems sufficient to justify the general conclusion that the sugar runs practically uniform regardless of the period of lactation, excepting that a decline of from 0.2 to 0.4 per cent may be looked for in most cases during the last 3 or 4 months. The increase of the total solids is not sufficient to account for this decline. If the results are calculated on the basis of the water content the same small decline is found.

TABLE 18.—*Average percentage of sugar for each cow, and breed average, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4	4.89	4.99	4.87	5.28	5.12	5.00	4.39	4.45	4.67	4.60	.....	.....	.....	.....
99	4.94	5.15	5.17	5.05	5.04	4.50	4.52	5.14	4.62	5.03	5.02	5.61	.....	.....
118	.....	4.47	4.70	4.56	4.83	5.21	5.20	5.40	4.57	4.73	4.90	4.72	4.46	5.22
Average for Jerseys	4.92	4.87	4.91	4.96	5.00	4.90	4.70	5.00	4.62	4.79	4.96	5.17	4.46	5.22
205	4.69	4.98	4.84	5.18	5.42	5.37	5.20	4.76	5.10	5.12	5.13	5.02	4.89	4.81
206	4.07	4.49	4.44	4.12	4.26	4.04	4.74	4.25	4.09	3.94	4.50	.....	.....	.....
209	4.40	4.00	4.17	3.95	4.42	4.36	4.16	3.94	4.43	4.62	4.79	4.15	4.30	.....
Average for Holsteins	4.39	4.49	4.48	4.42	4.70	4.59	4.70	4.32	4.54	4.56	4.81	4.59	4.60	4.81
300	5.14	4.81	4.64	4.87	4.96	4.57	4.82	5.08	5.13	4.39	.....	.....	.....	.....
301	5.17	4.72	5.62	5.16	4.77	3.95	5.38	5.13	4.85	4.88	4.89	5.04	5.13	.....
Average for Ayrshires	5.16	4.77	5.13	5.02	4.87	4.26	5.10	5.11	4.99	4.64	4.89	5.04	5.13	.....
400	5.40	5.06	5.44	5.13	5.87	4.95	5.05	5.19	4.65	4.22	4.25	.....	.....	.....
402	4.77	5.32	5.09	4.72	4.55	5.09	5.29	4.73	4.61	4.31	.....	.....	.....	.....
403	5.21	5.22	5.39	5.00	4.58	5.16	4.98	5.11	4.08	4.17	4.47	.....	.....	.....
Average for Shorthorns	5.13	5.20	5.31	4.95	4.67	5.07	5.11	5.01	4.45	4.23	4.36	.....	.....	.....
Grand total average	4.87	4.84	4.94	4.82	4.80	4.75	4.88	4.83	4.62	4.55	4.74	4.91	4.50	5.01

TOTAL SOLIDS.

Table 19 gives the total solids. The stage of lactation causes much the same variation with the total solids as is found with the fat and protein. First, there is a decline of about one-half per cent from the first to the second month. From this time on to the eighth or ninth month there is little change. The rapid decline in milk during the last 3 months of the lactation period is accompanied by a marked increase in the total solids. This general statement holds good for each of the 11 animals used in the investigation.

Table 19.—*Average per cent of total solids, for each cow and breed average, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
4	14.13	.....	.....	14.44	14.28	14.15	13.87	13.77	13.63	14.57	.....	.....	.....	.....
99	.....	13.09	13.30	13.15	12.92	12.76	13.04	12.81	13.35	14.27	15.15	16.08	.....	.....
118	.....	14.08	14.55	.....	.....	15.30	15.16	15.61	14.79	14.45	14.42	15.08	16.10	17.16
Average for Jerseys	14.13	13.59	13.93	13.80	13.60	14.07	14.02	14.06	13.92	14.43	14.79	15.58	16.10	17.16
205	11.74	11.58	11.70	11.95	12.11	11.77	11.98	12.16	11.95	12.12	12.20	12.50	13.04	13.42
206	10.95	10.10	10.18	10.27	10.54	10.73	10.75	10.80	11.01	11.90	13.30	.....	.....	.....
209	11.24	10.23	10.63	11.07	11.15	10.96	11.20	11.23	11.58	12.58	12.99	13.51	14.52	.....
Average for Holsteins	11.31	10.64	10.84	11.10	11.27	11.15	11.31	11.40	11.51	12.20	12.83	13.01	13.78	13.42
300	13.07	12.27	12.14	11.81	11.66	11.35	11.38	12.15	12.56	13.85	.....	.....	.....	.....
301	13.20	12.50	12.57	12.64	13.09	12.86	12.63	12.64	12.49	11.78	13.55	13.04	13.27	.....
Average for Ayrshires	13.14	12.39	12.36	12.23	12.38	12.11	12.01	12.40	12.53	12.82	13.55	13.04	13.27	.....
400	13.71	13.29	13.05	12.48	13.06	13.05	12.96	13.08	13.03	12.43	12.84	.....	.....	.....
402	13.74	13.29	13.07	13.07	13.16	12.97	13.02	12.93	13.81	13.94	.....	.....	.....	.....
403	12.85	12.16	11.75	11.56	11.56	11.65	12.77	12.52	12.38	12.90	13.19	.....	.....	.....
Average for Shorthorns	13.43	12.91	12.62	12.37	12.59	12.56	12.92	12.84	13.07	13.09	13.02	.....	.....	.....
Grand total average	12.74	12.26	12.29	12.24	12.35	12.50	12.61	12.70	12.78	13.16	13.46	14.04	14.23	15.29

Table 20 shows the average per cent of the total solids found as protein, casein, albumin, fat, and sugar, and the effect of the stage of lactation on this relation. The per cent of the total solids as ash is given for the general average only. On the average the total protein represents 27 per cent of the total solids, and at the end of the lactation period constitutes about 3 per cent more than at the beginning.

The casein increases slightly more than the total protein in per cent of the total solids. On the average this constituent makes up 22.1 per cent of the total solids. The albumin averages 2.3 per cent of the total solids and shows a decline in relation to the total solids at the end of the lactation period.

The fat represents 31.3 per cent of the total solids and shows a small variation during the lactation period in the way of an increase of about 2 per cent of the total solids near the end of the lactation period.

The sugar represents 37 per cent of the total solids on the average. The ratio is quite uniform until about the ninth month, when a decline begins which continues until the end of the lactation period. In the beginning the sugar constitutes 38.2 per cent of the total solids, and in the fourteenth period 32.8 per cent. The sugar, as already shown, remains practically constant until near the end of the milking period, when it declines somewhat. At the same time the other solids increase rapidly. As a result the ratio of the sugar to total nitrogen drops to a marked degree.

The ash, which shows practically no variation in amount during the lactation period, represents on the average 5.3 per cent of the total solids.

TABLE 20.—*Average per cent of total solids in the milk, and percentage as protein, casein, albumin, fat, sugar, and ash, by 4-week periods.*

Period No.	Total solids.	Water.	Per cent of solids as—					
			Protein.	Casein.	Albumin.	Fat.	Sugar.	Ash.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	12.74	87.26	25.5	21.0	2.35	31.4	38.2	....
2	12.26	87.74	24.9	19.2	2.34	31.4	39.5	....
3	12.29	87.71	24.9	20.3	2.07	30.8	40.2	....
4	12.24	87.76	25.6	20.3	2.08	30.8	39.4	....
5	12.35	87.65	26.3	21.2	2.12	30.9	38.9	....
6	12.50	87.50	26.0	21.4	2.14	30.3	38.0	....
7	12.61	87.39	26.3	21.3	2.17	30.4	38.7	....
8	12.70	87.30	26.1	21.6	2.11	30.3	38.0	....
9	12.78	87.22	27.9	22.5	2.20	31.1	36.2	....
10	13.16	86.84	29.1	23.2	2.33	31.2	34.6	....
11	13.46	86.55	28.9	23.7	2.47	31.4	35.2	....
12	14.04	85.96	29.0	24.1	2.54	32.3	35.0	....
13	14.23	85.70	30.4	25.6	2.06	32.8	33.0	....
14	15.29	84.71	26.7	24.2	1.88	33.2	32.8	....
Average	13.05	86.95	27.0	22.1	2.20	31.3	37.0	5.3

RELATIVE SIZE OF FAT GLOBULES.

Table 21 gives the relative size of the fat globules for each cow, and figure 13 shows the average for the 11 cows expressed graphically.

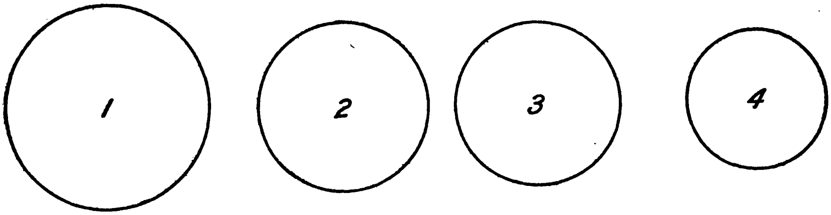

FIG. 13.—Relative size of fat globules as influenced by stage of lactation. (1) First 4-week period; (2) fifth 4-week period; (3) ninth 4-week period; (4) thirteenth 4-week period.

A determination such as this necessarily lacks the exactness of a determination like that for fat or nitrogen. However, 3 tubes were prepared from each sample and 3 readings taken from each tube according to the method given. An average of these 9 distinct counts for each sample reduces the variation to a minimum, and the further average of 4 separate samples, as given in the table, should give consistent results. It may be observed that the fat globules are especially large shortly after the beginning of the lactation period.

An examination of the weekly analyses in the Appendix will make the extent of the variation in size of fat globules clearer. It will be seen that in every case the cows began their lactation period with fat globules in relative size about twice the average for the milking period. The relative size declines sharply during the first six weeks, remains fairly constant for five or six months, after which the decline is much more rapid to the end of the lactation period.

It should be borne in mind that the relative size represents comparative volume and not diameter. To represent the comparative diameters of the globules it is necessary to extract the cube root of the figures representing the relative size.

In figure 13 the circles represent the comparative diameter of the average fat globules as found for the 11 cows during the first, fifth, ninth, and thirteenth 4-week periods.

TABLE 21.—*Relative size of fat globules in milk of each cow, and breed average, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
4	363	423	370	229	267	235	299	318	228	167	.....	.....	.....	.....
99	556	339	325	274	264	349	370	367	270	209	263	315	.....	.....
118	.....	1,280	417	879	358	373	301	334	335	259	342	229	.....	.....
Average for Jerseys	460	681	371	461	296	319	323	340	278	212	303	272	.....	.....
205	242	147	148	147	127	82	107	96	98	90	81	117	102	.....
206	253	269	124	157	134	155	132	110	96	74	79	.....	.....	.....
209	321	139	136	138	104	89	98	99	105	79	63	76	118	.....
Average for Holsteins	272	185	136	147	122	109	112	102	100	81	74	97	110	.....
300	235	163	148	135	115	133	93	80	75	129	.....	.....	.....	.....
301	232	189	142	155	165	178	163	151	146	114	146	93	110	.....
Average for Ayrshires	234	176	145	145	140	156	128	116	111	122	146	93	110	.....
400	442	593	317	245	250	277	231	197	214	179	194	.....	.....	.....
402	566	561	394	274	280	232	271	214	213	193	.....	.....	.....	.....
403	357	303	213	183	134	141	146	147	203	175	128	.....	.....	.....
Average for Shorthorns	455	486	308	234	221	217	216	186	210	182	161	.....	.....	.....
Grand total average	357	401	249	256	200	204	201	192	180	152	118	166	110	.....

It seems impossible to correlate the variation in relative size of the fat globules with the variation of any constituent of the milk. In the early part of the milking period a decline in the per cent of both fat and protein is accompanied by a decline in the size of the fat globules, while at the end of the lactation period the fat globules are the smallest and the fat and protein content are at the highest.

It might be reasonably expected that the relative size of the fat globules would bear some relation to the physical constants of the fat. Table 22 gives the average, by periods, of the relative size, melting point, iodin number, Reichert-Meissl number, and saponification number in order that such a comparison may be made.

The melting point rises as the relative size of the globules decreases. The change in the former, however, is not great, and a study of the weekly analyses shown in the table in the Appendix fails to indicate any special relation between these two characteristics in particular samples.

What is said of the relation of the relative size to the melting point may also be said of its relation to the iodin number. From the first period to the second the iodin drops with the size of the fat globules, but as the fat globules decline toward the end of the lactation period the iodin number goes strongly in the opposite direction.

The Reichert-Meissl number declines as the fat globules become smaller. The average results, as shown in Table 22 and in figure 14, seem to indicate a correlation between the size of the fat globules and the Reichert-Meissl number. An examination of the weekly samples from the table in the Appendix seems to bear out this statement.

TABLE 22.—*Relation of size of fat globules to physical constants of the fat.—Average determinations by 4-week periods.*

Period No.	Relative size.	Melting point.	Iodin number.	Reichert-Meissl number.	Saponification number.	Period No.	Relative size.	Melting point.	Iodin number.	Reichert-Meissl number.	Saponification number.
		°C.						*°C.*			
1	357	31.73	33.28	29.13	233.7	8	192	33.41	33.26	25.20	226.7
2	307	32.96	31.58	27.49	230.4	9	180	33.51	34.56	24.23	225.6
3	249	32.82	32.22	27.06	231.0	10	152	33.94	35.41	22.48	223.4
4	256	33.08	30.85	26.45	229.6	11	162	34.67	35.46	22.24	223.8
5	200	33.28	31.36	26.58	229.2	12	166	33.85	35.17	20.29	220.6
6	204	33.25	31.72	26.40	228.9	13	110	36.48	39.22	17.20	216.6
7	201	33.32	32.96	25.52	225.7						

MELTING POINT.

Table 23 gives details regarding the melting point of the fat for each animal. The same data are shown graphically in figure 14. With the exception of the last end of the lactation period, there was but little change in the melting point. The table in the Appendix gives the details of this determination by weeks. An examination of the table will show more clearly the variation that occurs at the beginning and end of the lactation period. There seems to be no uniformity in regard to the changes that are found in the melting point during the first few weeks of the lactation period. With three of the animals—namely, Nos. 301, 118, and 99—there is a decided increase in the melting point from the first to the third week. With Nos. 205, 206, 300, and 400 there is a decided decline for the same period, while the remaining 4 show practically no change. The averages of all the cows by 4-week periods show an increase from the first to the second period. These variations in the melting point at this time can not be attributed to the feed, since that was uniform. It is probable that the explanation lies in the extent to which fat was taken from the animal's body to supply that produced in the milk.

It has been found in other investigations not as yet reported that when an animal on account of insufficient feed declines rapidly in weight due to fat being removed from the body to support milk production, the melting point of this fat is raised, indicating that it has some of the characteristics of body fat. We also find that the fat produced during the first few days of the lactation period, during the stage before the milk is ordinarily used for food, always has an unusually high melting point. It is also possible that these variations in the melting point during the first week are influenced by the length of interval that elapsed before beginning the sample. The date of beginning the samples was governed by the condition of the cow, the plan being to begin as soon as the milk was deemed suitable for food purposes. In some cases the time that elapsed before the sampling was begun was only 5 days and in others as high as 10 days.

After the first 3 weeks very little change is noted in the melting point until that point in the lactation period is reached when the milk flow declines very rapidly and when all the constituents show a decided tendency to change. This occurred at about 2 months before the end of the lactation period. In several cases the melting point rose as much as 6° during the last 5 weeks, the most extreme figure being that for cow No. 205, where the melting point reached 52.9° C., while the average figure for the same cow was about 33° C.

It is impossible to say what changes take place in the composition of the fat that result in this rapid rise in the melting point near the end of the lactation period. It is accompanied by a high iodin number and an especially low Reichert-Meissl number. An examination in detail of the weekly analyses in the Appendix indicates that in most cases, for example, with cow No. 205, an extremely high melting point is associated with an unusually low Reichert-Meissl and saponification number and a correspondingly high iodin number. This indicates that the decline in volatile acids, which have a very low melting point compared with the other fats, far more than offsets the increase in olein indicated by a high iodin number, which would tend to lower the melting point. On the whole, the melting point seems to be little affected by the period of lactation when the feed is kept uniform, except at the extreme end, when abnormally high results may be expected.

TABLE 23.—*Average melting point of the fat for each cow, and breed average, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*	°*C.*
4	32.36	32.63	33.39	33.25	33.30	33.44	32.94	33.24	33.03	32.97	.....	.....	.....	.....
99	24.94	33.24	33.36	34.53	33.78	34.08	34.07	34.33	34.64	33.81	34.88	34.35	.....	.....
118	26.62	32.66	33.31	33.31	33.80	33.40	33.92	33.66	33.39	33.59	33.81	33.68	33.46	33.50
Average for Jerseys	27.97	32.84	33.35	33.70	33.63	33.64	33.64	33.74	33.69	33.46	34.35	34.02	33.46	33.50
205	33.41	32.67	33.39	33.76	33.02	32.93	32.88	32.98	33.26	33.09	33.01	32.54	41.80	48.34
206	32.95	33.52	31.94	32.06	32.47	32.47	32.64	33.13	32.81	32.92	38.80	.....	.....	.....
209	32.58	32.16	32.06	31.84	33.04	31.69	32.30	32.78	32.85	33.82	33.15	35.45	37.39	.....
Average for Holsteins	32.98	32.78	32.46	32.55	32.84	32.36	32.61	32.96	32.97	33.28	34.99	34.00	39.60	48.34
300	34.80	33.39	33.45	33.54	33.74	33.87	33.83	33.30	33.30	34.04	.....	.....	.....	.....
301	32.07	33.21	32.61	32.80	33.85	32.98	33.98	33.55	33.33	33.10	34.35	33.23	33.28	.....
Average for Ayrshires	33.44	33.30	33.03	32.17	33.80	33.43	33.91	33.43	33.32	33.57	34.35	33.23	33.28	.....
400	33.91	32.99	31.61	33.15	33.01	33.88	33.63	34.13	34.21	36.40	36.49	.....	.....	.....
402	32.69	32.79	33.20	33.09	32.95	33.99	33.76	33.79	34.65	36.31	.....	.....	.....	.....
403	32.70	33.32	32.70	32.60	33.15	32.98	32.54	32.65	33.14	33.28	32.92	.....	.....	.....
Average for Shorthorns	33.10	33.03	32.50	32.95	33.04	33.62	33.31	33.52	34.00	35.33	34.71	.....	.....	.....
Grand total average	31.73	32.96	32.82	33.08	33.28	33.25	33.32	33.41	33.51	33.94	34.68	33.85	36.48	.....

REFRACTIVE INDEX.

The refractive index of the fat was determined as mentioned with the Zeiss-Abbe refractometer under standard conditions. This determination was continued through the entire lactation period of 5 of the animals, and a number of determinations were made from samples representing the milk of the others. The results show a decided uniformity under all conditions. The determinations were finally dropped, since the variations found, due to the stage of lactation, were too small to be of any importance. The only variation that the data show at all is a slightly higher index in most cases during the first 2 or 3 weeks of the lactation period than was found during the remainder. We found no tendency for the refractive index to change during the last few weeks of the lactation period, as was found to be true of nearly every constituent of the milk, and also all the physical constants of the fat.

REICHERT-MEISSL NUMBER.

The Reichert-Meissl number, or the volatile acid determination, is considered one of the most important of the physical constants in connection with butterfat. The results of this determination by 4-week periods are found in Table 24 and are shown graphically in figure 14. In general there is quite a uniform decline from the beginning of the lactation period to the end, although this fluctuates with individual animals, as will be seen by inspecting the figures in detail. By eliminating these variations there is a marked decline with the advance in period of lactation.

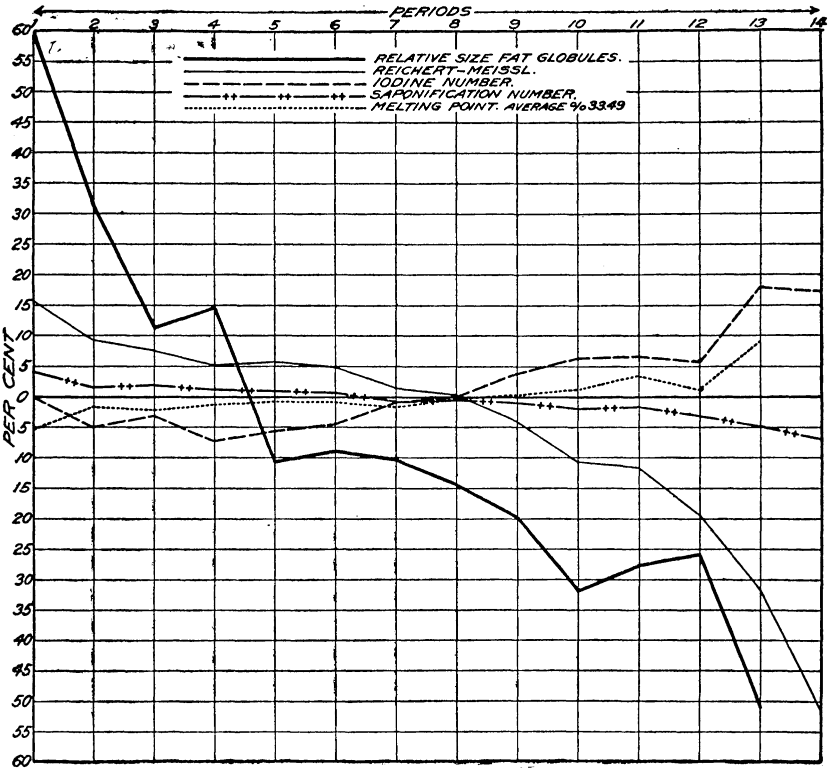

FIG. 14.—Variations in fat characters at end of each 4-week yeriod.

The total number of determinations made was 484; the lowest was 6.10 and the highest 33.38. The statement below shows the distribution of these determinations from the lowest to the highest and the per cent of the whole number that come within limits of 5.

	Per cent.
Between 5 and 10	0. 8
10 and 15	2. 2
15 and 20	4. 5
20 and 25	33. 9
25 and 30	50. 2
30 and 35	8. 2

Fifty per cent of the total number come between 25 and 30, while 7.5 per cent of the total number come below 20. Richmond considers butter with a Reichert-Meissl number less than 25 suspicious, and suggests that this number be adopted as the commercial limit. He also says that the absolute lowest limit must be fixed at 20. The statement given shows that 41.4 per cent of the determinations made were 25 or less, while 7.5 per cent went below the absolute limit as suggested by Richmond.[1]

The low figures here given are accounted for to a large extent by the fact that the cows were fed entirely on dry feed, while under commercial conditions fully two-thirds of the butter on the market is produced from animals that are consuming green feed, which is assumed to give a higher Reichert-Meissl number. The further explanation of the large number of low determinations is the fact that each sample represents an individual cow, and toward the end of the lactation period when these abnormal samples occur the production of milk and fat is low. As a rule butter that comes on the market is a mixture of fat from several animals, and only under exceptional conditions would it happen that all were at such a stage of lactation as to give such an abnormally low Reichert-Meissl number. However, it is entirely possible that such figures might be found where samples of butter come from small lots made from a limited number of cows, and this possibility should be taken into account.

The change in this constant, as is true with that of most of the others, is much more pronounced near the close of the lactation period, when the decline in milk production is rapid. As is the case with the melting point, variations in the Reichert-Meissl number during the first 5 or 6 weeks of the lactation period is irregular. In some cases there is a marked increase and in others a great decrease. The cause of this is probably to be explained in the same manner as was mentioned in connection with the similar variations of the melting point—that is, on account of the difference in the length of time represented from the date of calving and the probability that in some cases the animal was drawing on the reserve fat of the body and using it in forming milk fat, while in other cases this was not done.

The Reichert-Meissl number is more affected by the stage of lactation than any other of the physical constants with the exception of the relative size of the fat globules. The marked similarity between the curve representing these two will at once attract attention.

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[1] Richmond, Henry Droop. Dairy chemistry. London, 1899. See p. 262.

TABLE 24.—*Average Reichert-Meissl number for each cow, and breed average, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
4	29.22	28.72	28.52	28.50	28.96	29.20	26.87	28.63	25.24	25.95	.....	.....	.....	.....
99	30.16	28.88	32.09	30.95	27.67	31.21	27.03	27.34	27.03	25.83	24.73	18.43	.....	.....
118	29.54	23.28	24.14	23.69	23.90	24.64	26.66	23.12	25.04	22.85	22.79	20.22	14.23	14.21
Average for Jerseys	29.64	26.96	28.25	27.71	26.84	28.35	26.85	26.36	25.77	24.88	23.76	19.33	14.23	14.21
205	26.66	26.01	26.33	27.38	27.82	26.92	28.05	27.53	27.86	26.06	25.63	20.39	12.77	10.27
206	30.15	29.48	28.15	24.58	27.19	24.51	24.28	23.39	23.53	20.76	17.62	.....	.....	.....
209	25.65	26.84	25.10	27.05	24.82	24.68	22.79	23.47	24.23	20.17	21.32	20.70	21.14	.....
Average for Holsteins	27.49	27.44	26.53	26.34	26.61	25.37	25.04	24.80	25.21	22.33	21.52	20.55	16.96	10.27
300	27.66	28.96	27.76	25.76	26.83	25.76	24.57	23.87	23.09	17.96	.....	.....	.....	.....
301	30.59	27.09	26.58	25.13	24.88	26.79	25.59	26.40	24.42	24.36	18.09	21.72	20.67	.....
Average for Ayrshires	29.13	28.03	27.17	25.45	25.86	26.28	25.08	25.14	23.76	21.16	18.09	21.72	20.67	.....
400	30.77	29.31	25.95	25.99	28.58	26.54	24.70	25.99	24.46	22.57	22.25	.....	.....	.....
402	30.72	27.14	26.69	25.60	26.07	24.12	23.75	22.93	18.39	16.61	.....	.....	.....	.....
403	29.36	26.67	26.31	26.30	25.69	26.02	26.38	24.53	23.27	24.25	25.02	.....	.....	.....
Average for Shorthorns	30.28	27.71	26.32	25.96	26.78	25.56	24.94	24.48	22.04	21.14	23.64	.....	.....	.....
Grand total average	29.13	27.49	27.06	26.45	26.58	26.40	25.52	25.20	24.23	22.48	22.18	20.29	17.20	.....

IODIN NUMBER.

The iodin number, or Hübl number, was determined according to the official method. The results of this determination by 4-week periods are shown in Table 25. The average results for 11 cows are illustrated in figure 14. The total number of determinations made was 473, the lowest being 23.8 and the highest 49.4. The statement below shows how these determinations are distributed between the minimum and maximum variations. It will be seen that 47.4 per cent of the whole lie between 30 and 35, and 93.8 per cent of all range between 25 and 40.

	Per cent.
Between 20 and 25	0.4
25 and 30	21.5
30 and 35	47.4
35 and 40	24.9
40 and 45	5.4
45 and 50	0.4

With the beginning of the lactation period we find the same irregular results as mentioned in connection with the Reichert-Meissl number and the melting point. With 8 of the cows the iodin number declines from the first to the second month and in some cases the change is very striking. With 3 of the cows the change is the reverse from the first to the second month. The lowest point for the lactation period, according to the general average, is the fourth monthly period, after which there is a slight but gradual increase until to within 2 or 3 months of the end of the lactation period. The iodin number increases as a rule gradually until it reaches the highest point during the entire lactation period. Since the iodin number represents the olein, which is a soft fat with a low melting point, it would be assumed that an increase in this constituent of the fat would result in a decline in the melting point. The data given, however, show that in nearly every case the reverse is true. Even where the iodin number increases from an average of around 33 to 42 or 43, the melting point of the fat during the same period with some animals increased as much as 15°.

While there is no doubt that the tendency of the olein is to lower the melting point, its influence is counteracted by the stronger influence of the decline in the amount of butyrin. The melting point of butyrin is far below that of olein, and it therefore has a more marked effect upon the melting point. The amount of butyrin or butyric acid is indicated closely by the Reichert-Meissl number, and in all cases a high melting point is accompanied by a low Reichert-Meissl number, indicating that while a high olein usually goes with a high melting point the butyric acid is at the same time abnormally low. This results in a striking increase in the melting point, and these conditions are found mostly in the extremes of the lactation period, especially near the end.

TABLE 25.—*Average iodin number for each cow, and breed average, by 4-week periods.*

Cow No.	First Period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
4	31.08	28.04	29.61	29.94	28.84	28.03	31.46	29.75	32.27	32.15	.....	.....	.....	.....
99	32.68	29.46	28.96	26.75	29.99	27.29	27.93	27.37	28.71	28.80	27.61	29.55	.....	.....
118	39.31	36.33	32.54	28.69	31.55	30.43	28.67	32.49	33.67	31.43	31.14	32.47	38.48	35.82
Average for Jerseys	34.36	31.28	30.37	28.46	30.13	28.58	29.35	29.87	31.55	30.79	29.38	31.01	38.48	35.82
205	37.12	34.54	33.23	31.85	31.77	32.64	32.62	33.45	34.07	35.55	35.40	37.53	42.57	42.24
206	31.00	30.57	35.53	31.70	31.79	31.67	33.14	34.25	33.91	35.27	36.53	.....	.....	.....
209	39.46	33.32	32.89	33.10	33.53	34.91	36.63	35.59	37.01	39.08	35.35	36.69	39.03	.....
Average for Holsteins	35.86	32.81	33.88	32.22	32.36	33.07	34.13	34.43	35.00	36.63	35.76	37.11	40.80	42.24
300	32.58	28.70	27.69	31.91	27.50	29.61	35.30	37.32	35.23	37.74	.....	.....	.....	.....
301	28.58	29.91	30.56	29.85	30.93	30.31	31.04	30.54	32.64	35.11	44.11	39.62	36.80	.....
Average for Ayrshires	30.58	29.31	29.13	30.88	29.22	29.96	33.17	33.93	33.94	36.43	44.11	39.62	36.80	.....
400	30.13	32.12	39.05	31.36	31.66	33.31	35.71	33.25	34.28	36.91	38.49	.....	.....	.....
402	30.76	29.21	31.15	30.42	32.08	35.16	35.13	35.47	41.01	42.19	.....	.....	.....	.....
403	33.33	35.18	33.19	33.75	35.28	35.57	34.96	36.34	37.32	35.24	35.21	.....	.....	.....
Average for Shorthorns	31.41	32.17	34.46	31.84	33.01	34.68	35.27	35.02	37.54	38.11	36.85	.....	.....	.....
Grand total average	33.28	31.58	32.22	30.85	31.36	31.72	32.96	33.26	34.56	35.41	35.48	35.17	39.22	39.03

SAPONIFICATION.

The saponification or Koettstorfer number was determined according to the regular official method. Table 26 gives the results of this determination by 4-week periods for each animal.

A total of 488 determinations of the saponification number were made, among which the lowest found was 200.1 and the highest 252.3. The figures below show the range of variation expressed in percentage. About 81 per cent of the total number come between 220 and 235.

	Per cent.
Between 200 and 210	1.6
210 and 215	2.2
215 and 220	6.9
220 and 225	20.4
225 and 230	34.2
230 and 235	26.0
235 and 240	4.8
240 and 245	1.8
245 and 250	1.4
250 and 255	0.2

The period of lactation seemed to exert a uniform effect upon the saponification value with all of the 11 cows. In general there was an almost uniform decline from the beginning to the end, with the exception that during the last 3 months the decline was most marked. This decline coincides closely with the decrease in the volatile acids as shown by the Reichert-Meissl number. Such a decline in the saponification number would be expected from the decline in the Reichert-Meissl number, since the low molecular weight of the volatile acids have the effect of holding up the saponification number, and when they are decreased a corresponding decline is expected. This decline is so consistent and so uniform that it may be safely assumed that it is a natural effect of the period of lactation and may be looked for to show most in the last end of the lactation period, unless there is some other factor to interfere. The ratio between the saponification number and the Reichert-Meissl number is constant throughout the lactation period, which indicates that it may be a readjustment of the proportions of the higher fatty acids.

TABLE 26.—*Average saponification number for each cow, and breed average, by 4-week periods.*

Cow No.	First period.	Second period.	Third period.	Fourth period.	Fifth period.	Sixth period.	Seventh period.	Eighth period.	Ninth period.	Tenth period.	Eleventh period.	Twelfth period.	Thirteenth period.	Fourteenth period.
4	231.1	233.1	232.9	229.1	230.7	229.0	227.8	229.4	234.4	235.9	.....	.....	.....	.....
99	230.6	232.1	229.5	232.3	227.7	231.7	227.3	239.8	234.3	231.4	229.4	219.1	.....	.....
118	228.5	224.7	229.6	229.0	230.2	226.6	229.4	224.8	225.1	227.6	237.0	223.9	219.5	219.1
Average for Jerseys	230.1	230.0	230.7	230.1	229.5	229.1	228.2	231.3	231.3	231.6	233.2	221.5	219.5	219.1
205	242.2	229.3	229.0	232.9	230.8	228.7	228.1	227.0	225.0	223.9	226.3	220.8	210.1	205.9
206	230.7	228.3	242.4	233.7	232.4	231.2	229.7	225.6	224.4	219.9	216.4	.....	.....	.....
209	237.2	230.6	231.6	230.8	228.3	229.0	224.0	222.4	222.0	219.2	222.0	220.3	215.3	.....
Average for Holsteins	236.7	229.4	234.3	232.5	230.5	229.6	227.3	225.0	223.8	221.0	221.6	220.6	212.7	.....
300	232.6	230.7	232.3	224.8	229.2	230.1	224.5	222.0	223.9	217.2	.....	.....	.....	.....
301	236.9	234.1	232.0	230.4	227.5	229.7	219.6	228.3	228.4	224.3	216.2	218.7	221.3	.....
Average for Ayrshires	234.8	232.4	232.2	227.6	228.4	229.9	222.1	225.2	226.2	220.8	216.2	218.7	221.3	.....
400	232.3	231.7	224.2	230.0	229.4	227.2	223.9	226.5	224.9	220.5	216.8	.....	.....	.....
402	234.3	233.9	229.8	223.0	228.3	224.3	223.7	222.7	215.8	211.5	.....	.....	.....	.....
403	234.3	225.4	228.1	229.9	226.4	230.1	224.6	225.1	223.8	226.4	226.2	.....	.....	.....
Average for Shorthorns	233.6	230.3	227.4	227.6	228.0	227.2	224.1	224.8	221.5	219.5	221.5	.....	.....	.....
Grand total average	233.7	230.4	231.0	229.6	229.2	228.9	225.7	226.7	225.6	223.4	223.8	220.6	216.6	.....

ASH.

Ash determinations were not made on the 7-day samples; they were prepared by combining 4 of these weekly composite samples. The total ash in this combined sample was determined according to the official method. The results may be seen in Tables 4 and 5.

The amount of ash was found to be fairly uniform in all samples except that near the end of the lactation period there was some increase, which seems to be the only change that can be attributed to the stage of the lactation period. Our analyses did not include a determination of the several mineral constituents, which is of equal if not of greater importance than finding the total ash present.

However, Dr. August Trunz,[1] at the University of Halle in 1903, conducted a very careful and complete investigation concerning these mineral constituents of milk as affected by the lactation period, and in order to make this bulletin more complete an abstract of his work is herewith incorporated. Full credit is given Dr. Trunz for this work, and for complete details reference should be made to his original article. Only that part of his work which has to do directly with the ash will be discussed, although in his original paper he includes a study of other constituents.

Dr. Trunz's investigation was conducted with two cows. Cow 655 was a cross between a Simmenthaler and a Norderditmarscher. She was 3½ years old at the beginning of the experiment, calved December 25, 1901, and went dry November 8, 1902. She was fed no regular ration, receiving the same feed as the rest of the herd which was changed 2 or 3 times during the period. The other cow, No. 674, was a pure Friesian. She was 7½ years old at the beginning of the experiment, calved January 14, 1902, and went dry December 6, of the same year. Since she was used for the production of baby milk her ration was kept uniform throughout the year. She received the following ration per 1,000 pounds live weight:

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[1] Trunz, August. Über die mineralischen Bestandteile der Kuhmilch und ihre Schwankungen im Verlaufe einer Laktationsperiode. Zeitschrift für Physiologische Chemie, vol. 40, No. 3/4, pp. 263–310. Strassburg, Dec. 5, 1903.

Lucern hay	pounds	16
Barley straw	do	8
Oats	do	8
Linseed	do	1
Wheat bran	do	2

An analysis was made of the milk from each milking for 4 or 5 days after calving. After this, samples were taken at irregular intervals during the lactation period. Altogether 30 samples from each cow were analyzed. The total percentage of ash was determined as well as that of the various ash constituents, which included K^2O, Na_2O, CaO, MgO, SO_3, P_2O_5, Cl, and Fe_2O_3.

For the crude ash determination 40 to 50 grams of the milk were weighed into a platinum dish, evaporated to dryness, and then ignited at low redness until a perfectly white ash was obtained. The sample of ash for the determination of the individual constituents was obtained by evaporating about 1 liter of the milk in a nickel dish and igniting at low red heat. The soluble material, consisting largely of the alkaline chlorid, was extracted with hot water. The residue was then ignited at a somewhat higher temperature. Finally the two parts were united and evaporated to dryness in a platinum dish and then cautiously ignited and weighed. The ash secured in this manner was preserved in corked bottles until analyzed.

For the determination of the individual constituents 2.5 grams of the crude ash was weighed out, acidified with hydrochloric or nitric acid, and made up to 250 c. c. Then 50 or 100 c. c. of the filtered solution, corresponding to 0.5 or 1 gram of ash, was taken for analysis. The hydrochloric acid solution was neutralized with ammonia, treated with ammonium acetate, warmed, the iron phosphate filtered off, ignited and weighed. Half of this was considered to be ferric oxid.

From the filtrate, the calcium was precipitated as calcium oxalate and weighed as the carbonate and also as calcium oxid after igniting in the blast. The magnesium was precipitated from the concentrated filtrate as magnesium ammonium phosphate, and after ignition weighed as magnesium prophosphate.

In another 100 c. c. of the solution the sulphuric acid was precipitated as barium sulphate and the combined alkalies were determined in the filtrate as chlorids. The potassium was then determined by precipitation as potassium platinic chlorid and this calculated to potassium chlorid, subtracted from the combined chlorids to give the percentage of sodium chlorid.

The phosphoric acid was determined by the molybdate method and the chlorin by titration against deci-normal silver nitrate solution.

The author distinguishes between crude and pure ash, the former being what is usually considered as milk ash and the latter obtained by subtracting from the crude ash the mineral constituents combined with the proteids.

INDIVIDUAL COMPONENTS OF THE ASH.

Sodium and potassium.—Sodium and potassium underwent great variations in the course of the lactation period. In the colostrum period the percentage of potassium was lower than in the remainder of the lactation period, the first milking containing 16.15 and 17.98 per cent of K_2O in the total ash, which rose to 26.87 and 26.94 per cent at the time of the greatest secretion. It then fell slowly till the last two months, then rapidly to 16.89 per cent and 13.92 per cent at the end.

Excluding two figures which are abnormally high, the percentages of Na_2O show variations from 3.24 per cent to 8.5 per cent of the total ash for one cow and from 4.32 per cent to 8.56 per cent for the other. The tendency is for it to decline during the first half of the period and then rise during the second half.

Calcium oxid.—Excluding two abnormal figures, the calcium oxid varied between 23.88 per cent and 27.49 per cent for one cow and between 21.23 per cent and 25.78 per cent for the other, being somewhat higher in the colostrum. The variations were erratic and showed but slight change during the period.

Magnesium oxid.—The magnesium oxid varied from 4.52 per cent to 2.54 per cent and from 5.27 per cent to 2.51 per cent, falling during the first third and rising from then on to the end of the milking period. It was highest in the first milking of the colostrum.

Chlorin.—The chlorin in the case of one cow remained nearly constant during the entire period, being from 11.5 per cent to 12 per cent. In the case of the other it rose from 11.86 per cent to 24.77 per cent. The chlorin content of the crude ash and of the pure ash seemed to vary somewhat in their relation to each other.

Phosphoric acid.—In the case of the two cows, the crude ash of the colostrum period contained 26.60 to 31.46 per cent and 28.28 to 31.45 per cent phosphoric acid, respectively. The pure ash contained a somewhat smaller percentage, 24.02 to 26.97 per cent and 22.25 to 28.36 per cent, respectively.

With one cow there seemed to be irregular fluctuations which occurred at about the time of the changes in the food. The cow on the constant ration showed a gradual decline from an average of 30.36 per cent in the colostrum period to 25.58 per cent in the last 4 months, the last month showing a P_2O_5 content of 22.23 per cent.

Iron and sulphuric acid.—Iron and sulphuric acid were determined only to complete the analyses. They occur only in small amounts and do not undergo any considerable variation during the lactation period. Iron makes about 0.25 per cent to 0.5 per cent of the ash, and SO_3 about 1.5 to 2.5 per cent.

The author makes a distinction between the total nitrogen-containing substance and the total proteids, as will be noted in his tables. He determined the former by the ordinary Kjeldahl method and the latter by precipitation from the 10-times diluted milk by the addition of 15 to 20 c. c. of a solution made up of 190 c. c. 95 per cent alcohol, 8 grams 25 per cent acetic acid, and 4 grams tannic acid.

ADDITIONAL DATA FROM FIVE JERSEY COWS.

In addition to the data from the 11 animals used primarily for this investigation, we are able to make use of less complete data from 5 Jersey cows kept under somewhat different conditions. These 5 cows, which were registered Jerseys, are designated as Nos. 4, 43, 63, 62, and 27. The conditions under which these animals were kept differed from the 11 animals supplying the other data in three particulars, as follows: (1) They were not kept on a uniform ration throughout the milking period; (2) they were maintained at uniform weight; (3) they were kept farrow. On the other hand, the 11 animals used especially in this investigation were fed on a ration of uniform composition throughout the lactation period; no attempt was made to keep the weight uniform, and they were not kept farrow. The 11 cows were kept under what would be considered ordinary commercial conditions with the exception of uniformity in the ration. The 5 Jersey cows all received the same grain mixture, which remained unchanged throughout the entire year. During the greater part of the year they were fed corn silage and alfalfa hay, while for some 3 months during the summer season the corn silage was replaced by green alfalfa and green corn.

Composite samples of milk from the 5 Jersey cows were prepared by taking a definite number of cubic centimeters of milk per pound from each. These composite samples covered periods of 1 month each for Nos. 63, 43, and 4 and 10 days each for Nos. 62 and 27. Tables 27 and 28 give the analyses of these samples and the average weight of the animal for the periods represented.

TABLE 27.—*Data for 5 additional Jersey cows.—Determinations for 3 cows from composite samples taken at 30-day periods.*

COW NO. 63.

Thirty days, ending—	Milk.	Fat.	Nitrogen.	Sugar.	Ash.	Average weight.
	Pounds.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pounds.*
Oct. 25	[1] 500.2	5.90	0.69	4.70	0.778	960
Nov. 24	641.4	6.22	.72	3.83	.780	940
Dec. 24	579.0	6.50	.69	....	.741	941
Jan. 23	563.3	6.40	.67	4.08	.740	945
Feb. 22	523.6	6.43	.70	4.35	.741	938
Mar. 23	520.9	6.35	.70	4.60	.771	941
Apr. 22	590.0	6.60	.70	5.05	.795	952
May 22	463.3	6.28	.68	4.50	.744	922
June 21	470.6	5.77	.65	4.40	.713	939
July 21	419.9	5.57	.68	4.10	.707	959
Aug. 20	420.1	5.20	.66	4.53	.684	955
Sept. 19	323.0	5.40	.69	3.66	.703	974
Oct. 2	[2] 118.6	5.56	.67	4.28	.696	963

COW NO. 43.

Thirty days, ending—	Milk.	Fat.	Nitrogen.	Sugar.	Ash.	Average weight.
Oct. 25	[3] 920.5	4.60	0.57	5.30	0.710	825
Nov. 24	776.4	5.18	.59	5.45	.770	799
Dec. 24	680.0	5.42	.55	4.50	.747	811
Jan. 23	674.8	5.15	.52	4.55	.615	811
Feb. 22	652.5	5.35	.56	3.70	.707	803
Mar. 23	669.5	5.02	.55	4.10	.712	794
Apr. 22	634.9	5.20	.55	4.35	.720	803
May 22	615.6	5.03	.53	4.60	.728	784
June 21	586.8	4.80	.56	4.00	.697	792
July 21	619.0	4.20	.55	4.78	.664	812
Aug. 20	599.7	4.20	.57	4.49	.697	812
Sept. 23	[4] 509.8	4.30	.59	3.89	.609	835

COW NO. 4.

Thirty days, ending—	Milk.	Fat.	Nitrogen.	Sugar.	Ash.	Average weight.
Nov. 24	[5] 1,266.4	5.18	0.63	4.97	0.842	801
Dec. 24	631.5	5.67	.64	3.83	.768	817
Jan. 23	643.6	5.80	.62	....	.800	814
Feb. 22	623.2	5.95	.62	4.00	.760	813
Mar. 23	622.4	5.97	.65	4.20	.791	814
Apr. 22	524.3	6.10	.63	4.70	.792	807
May 22	454.3	5.72	.66	4.60	.702	806
June 21	454.7	5.40	.67	4.10	.661	823
July 21	489.9	5.17	.64	4.41	.737	851
Aug. 20	475.5	4.67	.65	4.36	.684	837
Sept. 19	426.1	5.00	.68	4.16	.732	854
Oct. 5	[6] 161.7	5.20	.70	4.36	.731	861

[1] 22 days. [2] 13 days. [3] 32 days. [4] 34 days. [5] 48 days. [6] 16 days.

TABLE 28.—*Data for 5 additional Jersey cows—Determinations for 2 cows from composite samples taken at 10-day periods.*

COW NO. 62.

Ten days ending—	Milk.	Fat.	Nitrogen.	Sugar.	Ash.	Average weight.
	Pounds.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Pounds.*
Oct. 15	115.9	5.14	0.63	5.08	0.763	888
Oct. 25	139.6	5.80	.63	4.85	.764	883
Nov. 4	147.3	5.20	.63	5.30	.761	882
Nov. 14	156.4	5.00	.62	....	.770	882
Nov. 24	150.2	5.30	.62	6.48	.765	884
Dec. 4	137.5	5.10	.63	....	.750	882
Dec. 14	135.2	5.60	.63	3.93	.761	880
Dec. 24	138.4	5.55	.63	4.61	.702	894
Jan. 3	134.9	5.10	.65	4.55	.768	895
Jan. 13	123.2	5.20	.62	5.00	.700	886
Jan. 23	119.4	5.60	.62	4.23	.750	894
Feb. 2	114.5	5.40	.63	4.43	.757	898
Feb. 12	112.0	5.55	.62	3.93	.754	904
Feb. 22	104.7	5.45	.65	3.52	.759	903
Mar. 3	104.8	5.30	.66	6.18	.700	912
Mar. 13	103.8	5.30	.65	4.48	.712	906
Mar. 23	98.8	5.20	.63	3.88	.735	909
Apr. 2	96.5	5.50	.64	4.85	.778	907
Apr. 12	87.9	5.10	.66	4.51	.785	919
Apr. 22	90.9	5.40	.60	4.30	.720	913
May 2	84.4	4.95	.58	5.00	.657	910
May 12	77.6	5.45	.64	4.70	.837	910
May 22	72.6	5.30	.61	4.40	.800	919
June 1	79.3	5.50	.60	3.50	.916	925
June 11	73.0	5.30	.62	4.50	.723	924
June 21	68.0	5.20	.64	4.20	.732	923
July 1	65.5	5.30	.63	4.40	.655	931
July 11	64.6	5.20	.60	4.61	.713	929
July 21	56.2	5.20	.59	4.58	.686	911
July 31	49.2	5.10	.58	4.55	.688	897
Aug. 10	45.6	5.00	.60	4.50	.690	884
Aug. 20	41.0	5.10	.60	4.25	.689	905

COW NO. 27.

Oct. 15	[1] 181.3	4.20	0.52	5.00	0.745	924
Oct. 25	292.6	6.20	.52	4.70	.744	857
Nov. 4	310.4	5.60	.52	5.30	.745	846
Nov. 14	325.5	5.25	.55	5.00	.723	861
Nov. 24	314.3	5.30	.56	....	.736	890
Dec. 4	289.2	5.10	.58	3.76	.730	879
Dec. 14	287.6	5.60	.59	4.40	.764	872
Dec. 24	283.0	5.40	.58	4.86	.698	861
Jan. 3	272.3	5.10	.61	5.03	.762	873
Jan. 13	274.9	5.60	.62	5.30	.691	865
Jan. 23	266.7	5.10	.64	4.30	.721	882
Feb. 2	240.5	5.60	.62	4.98	.677	865
Feb. 12	243.1	5.80	.64	4.83	.750	875
Feb. 22	234.6	5.75	.64	4.35	.727	872
Mar. 3	245.6	5.60	.66	5.08	.776	885
Mar. 13	243.9	5.75	.65	4.66	.812	883
Mar. 23	244.2	5.70	.65	3.90	.775	897
Apr. 2	235.0	5.70	.67	5.30	.771	888
Apr. 12	231.6	5.60	.68	4.96	.789	900
Apr. 22	242.3	5.60	.66	4.60	.787	902
May 2	243.9	5.50	.67	4.90	.737	899
May 12	236.6	5.55	.68	4.50	.758	902
May 22	218.4	5.50	.66	4.50	.754	914
June 1	222.2	5.70	.65	....	.852	924
June 11	204.0	5.90	.62	4.70	.841	925
June 21	191.1	5.70	.64	4.50	.767	929
July 1	173.8	5.70	.61	4.67	.711	926
July 11	194.3	5.50	.68	4.69	.660	932
July 21	189.3	5.40	.63	4.80	.704	899
July 31	182.8	5.40	.63	4.08	.655	901
Aug. 10	183.5	5.00	.65	4.50	.672	906
Aug. 20	182.2	5.30	.67	4.93	.646	928
Aug. 30	173.7	5.70	.62	4.58	.597	935
Sept. 9	184.9	5.60	.67	4.93	.660	938
Sept. 19	161.6	5.60	.71	3.79	.705	938
Sept. 29	162.6	5.80	.70	4.33	.703	937
Oct. 9	149.4	6.00	.69	4.35	.689	958

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[1] Only 6 days.

EFFECTS OF MAINTAINING THE ANIMALS AT UNIFORM WEIGHT.

This group of 5 cows was kept, as stated, as near as possible at uniform weight. Each animal was weighed at a stated hour each day, and the ration increased or diminished in quantity as might seem necessary in order to keep it at a stationary weight. However, it is impossible with a heavy milking cow to prevent the weight from declining during the first few weeks of the lactation period. It will be noticed that in the case of No. 27 there was a considerable decline at this time and a smaller decline with Nos. 43 and 63. This decline in weight, which indicates a drawing on the reserve material in the body for milk production, may be reasonably expected to exert considerable effect upon the composition and properties of the milk, and this has been found to be the case. Some results of it are noticeable in the tables presented.

POSSIBLE VARIATIONS DUE TO THE RATION.

While the ration given these animals was not exactly the same throughout the lactation period and varied to a small extent as between the individuals, it is not believed that this variation was of sufficient extent to bring about any large change in the composition of the milk produced.

EFFECT OF KEEPING THE COWS FARROW.

Keeping the cows farrow might be expected to account for considerable variation in results as compared with the 11 cows that were developing a fetus during the latter part of the lactation period. The tables show a marked uniformity in the composition of the milk throughout the lactation period with each of these animals. This is probably accounted for by the reasons given, and, furthermore, with the exception of No. 62 these cows were all still producing milk at the end of the 12 months included in the experiment. If the period covered by the investigation had continued until the cows ceased to produce milk, it is probable that there would have been more change in the composition of the milk. Still, with No. 62, where the data include the entire lactation period, there seems to be little change in the composition of the milk in the last periods. It is well understood that as a rule an animal that is farrow continues to produce milk for a longer time than one that is pregnant.

The smaller range of variation in the composition of the milk during the year for these 5 cows as compared with the 11 is due to the fact that they were farrow. The per cent of nitrogen remains practically stationary with all 5 of the animals with the exception that in the case of No. 27 it is low in the first few periods. The probable cause of this is discussed on page 42. The per cent of fat, like the nitrogen, does not show much variation during the lactation period, there being no noticeable increase even at the end of the 12 months. The per cent of sugar remains fairly constant, and agrees with the data of the 11 cows heretofore given in declining to some extent in the latter part of the lactation period. There is no noticeable change in the per cent of ash, unless it be a slight decline.

While the results as previously given for the 11 cows fairly represent the changes that take place during the lactation period under normal conditions, the data of the 5 animals here under consideration assist in pointing out what factors are responsible for the changes that take place during the normal lactation period.

GENERAL DISCUSSION OF THE RESULTS.

It is evident from the data presented that certain changes in the composition of milk may be expected under normal conditions to occur during the lactation period. The lactation period in regard to its effect upon the composition of milk may be divided roughly into three parts.

The first stage includes the interval from the time the secretion of milk begins until the composition reaches normal, and covers a period of from 3 to 6 weeks. After the birth of the calf the colostrum is first secreted, which contains, as is well known, an abnormally high per cent of protein and of ash. This extremely abnormal composition changes rapidly during the first 4 days. Milk is ordinarily considered to be fit for food about the fifth day, although the changes in the composition continue for some time. The per cent of total protein, as well as of fat, as a rule continues to decline for from 3 to 6 weeks. One prominent characteristic of the fat during this first stage is the extremely large globules which are found in the beginning of the period and which decline rapidly in size during the first few weeks. During this first stage the composition of the fat also shows an irregular variation from the normal. The iodin number is ordinarily higher than the average; likewise the Reichert-Meissl number and the saponification. As a rule the melting point is abnormally high during the first few days of the lactation period, but soon reaches normal.

The second stage in the lactation period begins when the composition of the milk becomes normal, and continues until a point is reached when a rapid decline in the quantity of milk produced begins. Ordinarily this occurs within about 6 weeks to 2 months from the end of the lactation period. The length of the second stage will depend upon the length of the time the cow produces milk, and to some extent upon the quantity. If the complete lactation period of the cow be

10 months, this second stage will cover under average conditions about 6½ months. During this interval the composition of the milk remains in general quite uniform. There is a slight increase in the latter part in the nitrogen and in the fat, but these are not marked. The sugar remains practically constant. The changes in the fat most noticeable are a gradual decline in the size of the fat globules, which is accompanied by a decline in the Reichert-Meissl number and in the saponification number.

The third stage in the lactation period in some cases has a rather definite line of division from the second stage; in others the change is gradual. It begins at that point when the decline in milk production becomes rapid on account of the end of the lactation period being close at hand, and ordinarily this change begins from 6 weeks to 2 months before the end of the lactation period. During this third stage the composition of the milk changes widely from the average for the entire period, and while the extent of these changes varies with different animals, they are uniform to the degree that they may be reasonably counted on to occur under all normal conditions. The per cent of total protein rises rapidly, followed by the fat, although on the average the protein makes slightly the larger increase. During this stage the total protein content may be one-third higher than that present during the middle of the lactation period. The casein and albumin remain in practically the same proportions. The fat undergoes marked variations at this time. The size of the fat globules becomes very small, the melting point rises to a marked degree, the iodin number increases, the Reichert-Meissl number becomes abnormally low, and the saponification number likewise shows a strong decline.

RELATION OF STAGE OF LACTATION TO USE OF MILK AS FOOD.

In carrying on the investigations herein reported no attempt was made to determine how long after parturition milk is fit for human food. It is evident from the wide variations caused by the lactation period, especially in the per cent of protein present, that it is of considerable importance in many cases to consider the stage of the lactation period of the animal furnishing the milk in connection with its use as food. For infant feeding especially the amount of protein present is one of the important questions, and since a variation of one-third may be expected in the protein due to the stage of lactation, this factor should be understood and taken into account in modifying milk for infant feeding. Where mixed milk of a herd is used wide variation due to this cause would naturally be less liable to occur, but where the source of supply is one animal or a limited number all in the same stage of lactation the importance of this factor as influencing the composition of the milk would be considerable.

RELATION TO CHURNING.

The plan for the investigation contemplated churning tests to be made at intervals in order to observe the effect of the stage of lactation upon the time required for churning. However, many difficulties were experienced in working out a method to be followed in dealing with cream from individual animals and a satisfactory method was not evolved until the investigation was too far advanced to yield results of sufficient importance to be given in detail. The partial results, however, corroborated the common observation that the milk of cows advanced in the period of lactation churns with difficulty. In fact, the cream from all the animals churned with more difficulty near the end of the lactation period, and with several the last few samples secured at the end of the lactation period could scarcely be churned at all. Samples from Nos. 205, 206, 209, and 118 were found which we were unable to churn after trying every method we could devise. Persistent and violent shaking of this cream in glass jars at temperatures ranging from 10° to 30° C. failed to show any sign of churning after several hours of such agitation where cream under ordinary conditions would churn in a few minutes. The cream was also mixed with water and reseparated with a centrifugal separator to reduce the amount of solids not fat, but the cream still refused to churn.

The methods ordinarily followed in getting the samples of fat for analysis had to be modified with these samples and the fat extracted with ether. All the samples that could not be churned were near the end of the lactation period. It was observed with these same animals that the cream churned more and more difficultly as the end of the lactation period approached until the stage was reached when it became impossible to churn the samples. The conditions bringing about this difficulty in churning will be made the object of further investigation, but from the data at hand it appears that it was associated with a high per cent of protein and small fat globules, and it is believed these two factors together are the main causes of the difficulties experienced.

ABNORMAL TASTE IN MILK AT END OF LACTATION PERIOD.

It was observed with cows 118, 99, 206, and 205 that near the end of the lactation period a strong abnormal taste and odor developed in the milk within 24 hours after it was drawn from the cow. The flavor present might be described as a rancid and bitter taste combined.

On June 17 samples of milk were taken from cows 209, 205, and 403. The former two were near the end of the milking period and the latter near the beginning. These samples were cooled at once to

10° C. and placed in an ice box that maintained the above temperature. Forty-eight hours later a slightly stale taste was observed in the milk of 209; that of 205 showed an extremely bad condition, a rancid, bitter taste strongly developed; the milk of 403 showed no abnormal taste. After 6 days the sample from 403 showed a slight acid coagulation and the mixed samples of 205 and 209 showed a hard coagulum floating on the surface.

On June 18 samples were again taken from cows 205, 209, and 403, were cooled to 10° C., and placed in the ice box. Twenty-four hours later a slightly abnormal taste was observed in 209, while the same taste, but much stronger, was observed in 205; the sample from 403 remained normal.

June 19 further samples were taken from the three cows above mentioned. No abnormal conditions could be observed in the samples when fresh, although a slight difference in flavor could be detected, making it possible to distinguish one sample from the other in this manner. An examination 14 hours later showed the sample from No. 403 was still normal, while the mixed samples of 209 and 205 had a slightly abnormal taste of the kind previously mentioned. This abnormal condition in the latter sample became rapidly worse.

Accurate observations were not made regarding the milk of cow 118, although the same abnormal taste was observed at the close of the lactation period.

The cause of this abnormal condition of the milk was not determined. The observations made showed conclusively that it was found only in the milk of certain cows near the end of the lactation period and that it was not in the milk when drawn from the cow, although even then the milk could be distinguished by taste from that produced by cows that were in the beginning or middle of the lactation period. The abnormal conditions described appeared within 12 hours and continued to increase as the milk became older. The abnormal condition developed freely within 12 hours when the milk was cooled to below 10° C. immediately after milking and kept at that temperature. This latter statement suggests that it was not the action of bacteria, as at 10° C. any common organism will grow so slowly that a decomposition of the milk to the extent of producing a strong rancid odor and bitter flavor within 12 hours can hardly be expected.

Numerous inquiries are received each year regarding abnormal flavor in milk from cows near the end of the lactation period. The conditions described in this correspondence indicate that the abnormal taste and odor found in the milk of certain of the experimental animals is not uncommon in the milk of cows kept under commercial conditions.

SUMMARY.

1. Eleven purebred cows, consisting of 2 Ayrshires and 3 each of the Jersey, Holstein-Friesian, and Shorthorn breeds, were kept through an entire lactation period on a ration of uniform composition consisting of 2 parts of alfalfa hay to 1 part of grain. The latter was a mixture of 1 part oats, 1 part bran, and 8 parts cornmeal. This ration was varied in quantity to suit the individual animal. The cows were kept under normal conditions except in regard to the uniformity of the ration, and all remained in good health. The milk and fat produced were normal for the breeds.

The object of the investigation was primarily to study the effects during a normal period of lactation upon the composition and properties of the milk, disregarding changes that might be due to other sources.

2. Composite samples were prepared from the milk of each cow by 7-day periods. The following analyses and determinations were made: Specific gravity, dry matter, total nitrogen, nitrogen as casein, nitrogen as albumin, fat, sugar, and ash. The physical constants of the fat were determined as follows: Relative size of the fat globules, Reichert-Meissl number, iodin number, saponification number, refractive index, and melting point. The methods of the Association of Official Agricultural Chemists were followed.

3. The total protein was found to be abnormally high following parturition and continued to decline until the third or fourth week, when the minimum was reached. It then remained fairly constant until near the end of the lactation period, when it rose rapidly and reached the maximum at the end of the period. The range in the total protein on the average was more than that for the fat.

The casein constituted 80 to 82 per cent of the total protein and seldom went beyond these limits. It showed the same changes during the lactation period as described for the total protein.

The determination of the nitrogen as albumin by the official method was unsatisfactory. Eliminating minor variations, the albumin bears almost a constant ratio to the total protein and therefore follows the same variations during the lactation period.

On the average, 81.4 per cent of the total protein is casein, and from 7 to 9 per cent was determined as albumin. No relation was found between the protein and the sugar.

4. The per cent of fat on the average declined during the first 3 months, followed by a period of 4 to 5 months with but little change. From this point a rapid increase was found to the end of the lactation period.

The variations in the fat and protein were on the whole quite similar. Sudden variations in the per cent of fat are, however, not accompanied by corresponding changes in the protein, but gradual changes in the fat go with corresponding variations in the protein. On the average there is 0.86 pound of protein and 0.71 pound of casein to 1 pound of fat. Therefore, for each pound of protein on the average there was found 1.16 pounds of fat.

5. The lactose is the least variable of the constituents except the ash. The only change that is attributable to the stage of lactation is a slight decline near the close.

6. The total solids show the same variation as the fat and protein, i. e., a slight decline at first, then practically no change for 8 or 9 months, followed by a rapid increase to the end of the lactation period.

The total protein averaged 27 per cent of the total solids, the casein 22.1 per cent, the albumin 2.3 per cent, fat 31.3 per cent, sugar 37 per cent, ash 5.3 per cent.

7. Ash determinations were not made on the 7-day samples. They were made by combining 4 of the 7-day samples. The amount of ash was quite uniform through the lactation period except near the end, when there was some increase accompanying the increase in the total solids.

8. The milk of 5 additional Jersey cows was analyzed practically through a lactation period. The rations given these cows were not entirely uniform for the year. The cows were kept farrow and at a uniform weight.

The range of variation in the milk of these cows was less than with those kept under normal conditions. The per cent of both nitrogen and fat remained practically stationary with no increase even at the end of 12 months.

9. The stage of lactation exerts a marked and uniform effect upon the relative size of the fat globules. The fat globules are especially large immediately after the beginning of the milking period, then the relative size declines sharply during the first 6 weeks, remains fairly constant for 5 or 6 months, after which the decline is much more rapid to the end of the lactation period. Variation in the relative size can not be correlated with the variation of any of the constituents of the milk. The Reichert-Meissl number is the only physical constant of the fat that can be correlated in any way with the relative size of the fat globules. The data indicate that the small fat globules are accompanied by a low Reichert-Meissl number.

10. The melting point of the butterfat was not influenced to any great extent by the stage of lactation. During the first few weeks there is a lack of uniformity in results, in some cases a high melting point in the beginning and in others a low. The high melting point in the beginning of the lactation period which occurs in most cases is probably brought about by the animal utilizing the body fat, since the ration fed at that stage of lactation is usually below the require-

ments of the body. After the first few weeks the melting point remains practically constant until near the end of the lactation period, when it rises. The rise in the melting point is accompanied by a high iodin number and an especially low Reichert-Meissl number. On the whole the melting point is little affected by the period of lactation when the food is kept uniform, except at the latter end, when abnormal figures may be expected.

11. The refractive index was not affected to any appreciable extent by the stage of lactation.

12. The Reichert-Meissl number showed a uniform decline on the average from the beginning to the end of the lactation period. Of the total number of analyses, 41.6 per cent came below 25, which is the standard set as a commercial limit for butter, while 7.5 per cent of the total number came below 20. In the beginning of the lactation period the variations in the Reichert-Meissl number were irregular. From this time on there was a gradual decline until near the end, when it became more marked. The Reichert-Meissl number is more influenced by the stage of lactation than any other of the physical constants except the relative size of the fat globules.

13. The iodin number ranged from 23.8 to 49.4, while 47.4 per cent of the whole were between 30 and 35. A lack of uniformity is found in the beginning of the lactation period. After this stage is passed there is a slight but gradual increase until near the end, when it increases more rapidly until the highest point is reached at the end.

14. The stage of lactation exerts a uniform effect upon the saponification value. There is a uniform decline from the beginning to the end of the lactation period, with the exception that the decline is more rapid during the last 3 months. The decline is uniform with the decrease in volatile acids. The lowest figure among the 488 determinations was 200.1, and the highest 252.3, while 80.6 per cent of the total number came between 220 and 235.

15. The churning of the cream became more difficult toward the end of the lactation period, and with some cows samples were found that could not be churned under any conditions.

16. An abnormal odor and flavor developed in the milk of certain cows when near the end of the lactation period. This condition was not present in the freshly drawn milk but appeared within 12 hours, even when the milk was held at 10° C.

APPENDIX.

As previously mentioned, a composite sample of the milk of each cow in this investigation was taken every 7 days. The detailed analyses of these 7-day samples for each of the 11 cows is given in Table I.

TABLE I.—*Analysis of the milk of each cow, by 7-day periods.*

COW NO. 4.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.	Relative size of globules.
1906.		*P.ct.*	*P.ct.*	*P. ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*					*°C.*	
Dec. 1	1.0390	0.52	0.46	......	5.60	......	......	......	......	27.52	36.10	231.2	1.4602	32.35	524
8	1.0310	.52	......	0.052	5.37	......	......	......	4.80	32.06	32.13	228.6	1.4603	32.65	332
15	1.0340	......	.41	.066	5.10	......	......	......	5.00	29.40	30.64	233.4	1.4602	32.35	333
22	1.0340	......	......	......	4.62	85.87	14.13	9.51	4.88	27.88	25.43	231.1	1.4598	32.10	264
29	1.0320	.57	......	.059	4.95	......	......	......	5.08	30.67	29.90	230.3	1.4594	32.35	420
1907.															
Jan. 5	1.0330	.49	.40	.048	4.35	......	......	......	5.40	27.43	25.16	234.5	1.4597	32.25	441
12	1.0340	.55	.40	.058	4.60	......	......	......	4.95	29.06	28.78	235.2	1.4594	33.13	540
19	1.0340	.51	.34	.057	4.60	......	......	......	4.51	27.72	28.34	232.2	1.4595	32.80	289
26	1.0335	......	......	......	4.40	......	......	......	4.97	27.81	......	233.8	......	......	....
Feb. 2	1.0332	.53	.46	.047	5.10	......	......	......	4.87	28.05	28.14	231.9	1.4593	33.77	366
9	1.0340	.60	.47	.058	5.60	......	......	......	4.64	29.67	30.62	231.6	1.4576	32.55	422
16	1.0345	.58	.51	.066	5.17	......	......	......	5.00	28.55	30.06	234.2	1.4596	33.85	321
23	1.0344	.58	.47	.062	4.60	......	......	......	5.16	31.13	28.43	233.3	1.4594	33.41	213
Mar. 2	1.0332	.61	.49	.081	5.07	85.61	14.39	9.32	5.22	27.80	27.90	230.1	1.4593	33.37	242
9	1.0345	.62	.51	.067	4.66	85.60	14.40	9.74	5.46	27.86	29.78	223.8	1.4595	33.05	207
16	1.0337	.62	.49	.059	5.06	85.46	14.54	9.48	5.22	27.22	33.64	229.1	1.4593	33.15	255
23	1.0330	.59	.46	.050	4.93	85.59	14.41	9.48	4.90	28.88	32.09	230.4	1.4590	33.17	353
30	1.0336	.59	.48	.043	4.83	85.82	14.18	8.35	5.10	30.26	37.26	228.8	1.4590	33.50	318
Apr. 6	1.0345	.61	.48	.062	4.80	85.74	14.26	9.46	5.48	27.36	28.03	232.4	1.4597	33.08	239
13	1.0340	.62	.49	.023	4.68	......	......	......	5.00	29.32	27.96	231.3	1.4595	33.45	156
20	1.0340	.62	.50	.029	5.02	85.69	14.31	8.29	5.08	31.88	26.88	230.6	1.4591	33.27	251
27	1.0337	.58	.47	.031	4.83	86.01	13.99	9.16	4.88	28.53	27.93	229.5	1.4588	33.20	241
May 4	1.0330	.56	.47	.037	5.14	85.82	14.18	9.04	5.14	28.07	30.39	224.2	1.4596	33.30	199
11	1.0340	.58	.49	.027	5.00	85.89	14.11	9.11	4.95	28.32	26.93	231.8	1.4591	34.00	250
18	1.0315	.59	.47	.044	4.97	86.02	13.98	9.01	4.40	25.77	29.17	229.2	1.4591	33.30	207
25	1.0335	.60	.50	.058	4.68	86.15	13.85	9.17	4.63	21.89	33.72	225.6	1.4596	32.40	474
June 1	1.0325	.55	.42	.089	4.77	86.12	13.88	9.11	4.08	28.67	31.50	227.2	1.4596	33.15	266
8	1.0330	.60	.49	.066	4.50	86.24	13.76	9.26	4.44	29.54	......	229.3	1.4572	32.90	249
15	1.0322	.58	.47	.054	4.38	86.52	13.48	9.10	......	27.85	29.59	228.5	1.4593	33.15	346
22	1.0331	.58	.47	.063	4.44	86.39	13.61	9.17	4.43	27.83	29.60	229.5	1.4591	32.97	217
29	1.0330	.58	.45	.066	4.26	85.77	14.23	9.97	4.26	29.06	29.83	229.9	1.4594	33.55	336
July 6	1.0323	.54	.46	.061	4.94	......	......	......	4.67	29.77	29.98	229.6	1.4598	33.30	374
13	1.0340	.59	.47	.068	4.80	......	......	......	......	......	......	......	......	......	362
20	1.0330	.61	.50	.046	4.89	......	......	......	4.52	25.75	32.91	227.3	1.4600	32.90	198
27	1.0336	.64	.51	.057	4.57	86.04	13.96	9.39	4.67	25.44	31.34	231.5	1.4580	32.85	190
Aug. 3	1.0330	.63	.50	.076	4.65	86.71	13.29	8.64	4.83	24.52	32.55	244.4	1.4562	33.35	161
10	1.0340	.63	.50	.071	4.85	85.97	14.03	9.18	4.73	25.90	31.49	248.1	1.4593	32.80	186
17	1.0340	.66	.53	.061	5.15	85.30	14 70	9.55	4.83	25.81	31.42	246.2	1.4577	32.30	184
24	1.0340	.70	.53	.054	4.82	85.45	14.55	9.73	4.44	26.50	32.62	227.2	1.4597	33.20	141
31	1.0328	.65	.51	.058	5.39	85.25	14.75	9.36	4.56	25.66	33.05	230.5	1.4574	33.52	189
Sept. 7	1.0340	.67	.53	.069	5.68	85.20	14.80	9.12	4.42	25.87	32.18	227.6	1.4577	33.02	137

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 99.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	S a p onification number.	Refractive index.	Melting point.	Relative size of globules.
1907.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*					°*C.*	
Jan. 12	1.0340	0.55	0.43	0.054	5.00	......	......	......	5.10	30.70	29.38	229.2	1.4604	21.25	865
19	1.0340	.52	.44	.042	5.45	......	......	......	4.87	30.40	......	225.7	1.4602	21.30	561
26	1.0320	.51	.40	.022	5.25	......	......	......	5.02	29.86	34.25	238.0	1.4602	......	435
Feb. 2	1.0315	.46	.42	.033	5.17	......	......	......	4.78	29.69	34.41	229.3	1.4596	32.27	361
9	1.0330	.51	.41	.074	5.20	......	......	......	......	27.09	28.31	237.1	1.4602	33.55	508
16	1.0320	.52	......	.047	5.00	......	......	......	5.18	29.52	30.38	233.5	1.4594	32.65	361
23	1.0326	.49	.40	.041	4.60	......	......	......	4.93	28.02	30.46	229.8	1.4595	33.17	203
Mar. 2	1.0333	.50	.42	.052	4.37	86.91	13.09	8.72	5.33	30.89	28.69	228.0	1.4597	33.57	282
9	1.0334	.53	.45	.067	4.55	86.46	13.54	8.99	5.55	31.99	29.64	226.0	1.4594	32.60	305
16	1.0330	.51	.41	.027	4.51	86.51	13.49	8.98	5.27	32.04	32.94	231.3	1.4594	33.10	273
23	1.0340	.48	.35	.026	4.53	86.57	13.43	8.90	4.40	31.37	27.11	230.0	1.4592	33.50	418
30	1.0326	.50	.40	.027	4.14	87.28	12.72	8.58	5.45	32.95	26.13	230.7	1.4588	34.22	305
Apr. 6	1.0323	.48	.39	.024	4.50	86.80	13.20	8.70	5.01	30.99	26.80	231.7	1.4592	33.97	252
13	1.0327	.50	.42	.029	3.86	87.13	12.87	9.01	5.10	31.33	26.70	234.1	1.4594	34.07	233
20	1.0329	.51	.41	.024	4.74	86.50	13.50	8.76	5.17	31.52	28.16	231.6	1.4587	34.72	283
27	1.0324	.47	.39	.024	4.50	86.96	13.04	8.54	4.90	29.97	25.34	231.9	1.4584	35.35	328
May 4	1.0320	.46	.39	.022	4.39	87.16	12.84	8.45	5.18	......	......	......	......	......	259
11	1.0330	.50	.41	.021	4.32	87.05	12.95	8.63	5.18	30.90	28.55	229.4	1.4594	34.00	229
18	1.0327	.48	.38	.031	4.31	87.12	12.88	8.57	4.64	28.76	28.35	230.1	......	34.15	293
25	1.0310	.51	.40	.040	4.28	87.01	12.99	8.71	5.15	23.34	33.07	223.6	1.4600	33.20	275
June 1	1.0318	.47	.39	.048	4.32	87.13	12.87	8.55	4.68	31.51	28.41	232.2	1.4592	33.55	335
8	1.0322	.51	.40	.046	4.23	87.16	12.84	8.61	4.57	31.34	......	230.0	1.4593	34.83	305
15	1.0305	.48	.40	.037	4.43	87.10	12.90	8.47	4.48	30.79	26.17	231.8	1.4588	33.85	538
22	1.0310	.48	.39	.039	3.90	87.58	12.42	8.52	4.25	......	......	232.6	1.4588	......	217
29	1.0310	.47	.39	.036	4.27	86.96	13.04	8.77	4.38	30.16	23.80	225.9	1.4594	34.30	267
July 6	1.0320	.47	.38	.040	4.20	......	......	......	5.03	23.89	33.28	223.8	1.4603	33.45	259
13	1.0300	.49	.39	.041	4.40	......	......	......	3.96	......	......	......	......	......	618
20	1.0320	.49	.39	.028	4.56	......	......	......	4.71	27.04	26.70	232.1	1.4592	34.45	334
27	1.0309	.47	.38	.031	3.93	87.33	12.67	8.74	4.38	26.96	27.18	230.2	1.4571	34.55	736
Aug. 3	1.0320	.50	.41	.038	4.30	87.50	12.50	8.20	5.85	27.50	27.32	248.4	1.4569	34.30	265
10	1.0330	.51	.39	.048	4.42	86.87	13.13	8.71	5.25	26.81	27.68	231.4	1.4590	33.95	242
17	1.0330	.50	.40	.047	4.07	87.05	12.95	8.88	5.06	28.08	27.29	249.0	1.4588	34.50	224
24	1.0340	.52	.42	.041	4.37	86.87	13.13	8.76	4.53	27.76	28.47	228.2	......	34.37	182
31	1.0325	.52	.41	.030	4.80	86.66	13.34	8.54	4.41	27.42	28.70	234.4	1.4531	35.17	328
Sept. 7	1.0327	.51	.41	.041	4.70	86.34	13.66	8.96	4.78	27.16	28.52	233.8	1.4570	35.10	209
14	1.0320	.52	.45	.029	4.63	86.74	13.26	8.63	4.76	25.78	29.16	240.7	1.4546	33.92	359
21	1.0324	.54	.45	.036	4.74	86.15	13.85	9.11	4.80	22.93	28.11	233.9	1.4547	34.40	212
28	1.0355	.57	.45	.043	4.71	86.00	14.00	9.29	4.94	27.34	28.96	231.4	1.4549	34.15	202
Oct. 5	1.0345	.57	.45	.042	5.08	85.45	14.55	9.47	4.98	23.31	28.61	229.8	1.4564	34.10	226
12	1.0325	.57	.48	.049	5.39	85.34	14.66	9.27	5.38	29.72	29.53	230.3	1.4571	32.60	196
19	1.0340	.60	.50	.037	5.26	85.17	14.83	9.57	5.05	28.29	28.98	233.8	1.4564	34.35	195
26	1.0350	.61	.55	.033	5.78	84.68	15.32	9.54	5.18	21.74	26.38	231.5	1.4565	34.45	244
Nov. 2	1.0360	.64	.48	.046	6.00	84.39	15.61	9.61	5.08	25.30	24.62	227.9	1.4565	35.70	357
9	1.0323	.61	.50	.051	5.42	85.15	14.85	9.43	4.78	23.60	30.45	224.4	1.4561	35.00	255
16	1.0346	.64	.53	.068	5.99	84.11	15.89	9.90	5.28	21.99	27.62	224.0	1.4569	33.55	283
23	1.0335	.67	.52	.058	6.15	83.89	16.11	9.96	5.36	18.65	29.90	217.0	1.4553	34.95	367
30	1.0349	.68	.54	.087	6.07	83.76	16.24	10.17	6.20	14.64	31.12	217.7	1.4579	34.55	294

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 118.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	S a p onification number.	Refractive index.	Melting point.	Relative size of globules.
1906.		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*					°*C.*	
Oct. 13	......	......	......	......	......	......	......	......	......	28.75	42.54	232.6	1.4606	17.57	....
20	......	......	......	......	......	......	......	......	......	32.59	38.29	228.6	1.4604	30.47	....
27	......	......	......	......	......	......	......	......	......	27.29	37.11	224.4	1.4603	31.82	....
Nov. 3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	....
10	1.0300	0.48	......	......	5.06	86.07	13.93	8.87	4.60	24.97	34.37	226.6	1.4610	......	....
17	......	......	......	......	......	......	......	......	......	......	......	......	......	......	....
24	1.0310	.54	......	0.081	5.10	85.81	14.19	9.09	4.43	22.33	37.19	223.8	1.4606	32.82	....
Dec. 1	1.0297	.52	0.32	......	5.77	85.88	14.12	8.35	4.39	22.55	37.42	223.6	1.4608	32.50	1280
8	1.0229	.55	.49	.040	5.80	......	......	......	......	22.11	37.35	223.5	1.4609	32.72	449
15	1.0320	.....	.46	.057	5.60	......	......	......	......	23.11	26.76	235.4	1.4603	33.55	441
22	1.0320	.....	......	.033	5.58	85.45	14.55	8.97	4.66	25.98	33.32	231.7	1.4603	33.20	348
29	1.0340	.57	......	.073	5.20	......	......	......	4.73	25.36	32.71	227.7	1.4602	33.75	431
1907.															
Jan. 5	1.0335	.51	.42	......	5.00	......	......	......	5.51	24.82	26.18	229.1	1.4600	33.15	492
12	1.0320	.50	.38	.081	5.40	......	......	......	4.32	23.76	25.30	230.2	1.4603	33.37	1690
19	1.0320	.55	.42	.058	5.00	......	......	......	4.15	23.46	32.15	225.5	1.4601	33.40	710
26	1.0320	.58	.46	.033	5.05	......	......	......	4.25	22.73	31.13	231.0	1.4603	......	625
Feb. 2	1.0336	.58	.53	.036	5.00	......	......	......	4.85	23.97	31.58	227.4	1.4599	33.97	435
9	1.0345	.65	.56	.088	5.32	......	......	......	4.74	23.07	32.26	233.3	1.4602	33.67	394
16	1.0331	.70	......	.084	5.70	......	......	......	4.95	23.80	30.60	234.3	1.4598	34.07	342
23	1.0348	.65	.53	.086	6.00	......	......	......	4.77	24.77	31.74	225.9	1.4600	33.47	260
Mar. 2	1.0340	.64	.51	.087	5.80	84.90	15.10	9.30	5.01	24.71	29.96	227.4	1.4599	33.60	366
9	1.0350	.67	.53	.078	5.60	84.60	15.40	9.80	5.50	22.27	31.40	222.9	1.4597	32.90	374
16	1.0345	.66	.54	.058	5.69	84.59	15.41	9.72	5.22	25.59	31.53	225.7	1.4597	33.30	238
23	1.0345	.62	.51	.062	5.76	84.70	15.30	9.54	5.10	26.00	28.81	230.3	1.4589	33.80	512
30	1.0342	.64	.52	.042	5.44	85.29	14.71	9.27	5.03	27.56	27.83	231.0	1.4596	34.32	346
Apr. 6	1.0340	.67	.53	.048	5.86	84.72	15.28	9.42	5.15	27.47	28.91	230.8	1.4596	33.40	290
13	1.0350	.68	.53	.058	5.57	......	......	......	5.30	26.39	29.20	230.5	1.4595	33.75	342
20	1.0345	.67	.57	.049	5.87	84.51	15.49	9.62	5.32	25.23	28.74	225.1	1.4598	34.22	224
27	1.0345	.64	.53	.062	6.10	84.50	15.50	9.40	5.02	24.88	32.29	228.8	1.4600	33.42	337
May 4	1.0350	.63	.54	.053	5.95	83.88	16.12	10.17	5.53	20.84	33.99	225.9	1.4601	33.80	340
11	1.0350	.66	.56	.046	5.28	84.65	15.35	10.07	5.55	24.09	32.99	220.2	1.4602	33.65	336
18	1.0340	.64	.53	.067	5.86	84.53	15.47	9.61	5.50	22.66	30.69	224.2	1.4603	33.77	323
25	1.0350	.66	.53	.060	5.37	84.64	15.36	10.00	4.58	25.22	31.56	228.5	1.4600	33.55	240
June 1	1.0338	.64	.51	.061	5.41	84.80	15.20	9.80	4.43	25.28	35.37	221.6	1.4600	33.95	283
8	1.0340	.64	.50	.065	4.89	85.45	14.55	9.66	4.52	25.22	34.70	224.5	1.4604	33.25	351
15	1.0334	.62	.50	.063	4.99	85.94	14.06	9.07	4.73	24.42	33.03	225.8	1.4601	32.80	467
22	1.0320	.63	.51	.071	4.51	86.02	13.98	9.47	4.48	24.62	30.51	226.2	1.4596	33.57	189
29	1.0350	.63	.49	.071	4.83	85.17	14.83	10.00	4.72	22.00	32.53	227.9	1.4574	33.72	331
July 6	1.0342	.66	.50	.064	5.00	85.47	14.53	9.53	5.20	21.94	31.26	228.6	1.4596	33.47	230
13	1.0330	.65	.51	.070	3.54	......	......	......	4.52	......	......	......	......	......	286
20	1.0350	.65	.51	.050	5.00	......	......	......	4.55	23.73	30.42	228.9	1.4598	33.08	348
27	1.0342	.65	.51	.058	4.61	85.67	14.33	9.72	4.50	22.48	31.80	228.0	1.4561	34.55	523
Aug. 3	1.0354	.65	.51	.065	5.15	85.35	14.65	9.50	5.45	22.30	31.38	246.3	1.4555	34.15	228
10	1.0350	.65	.51	.075	4.57	85.71	14.29	9.72	5.10	22.64	30.95	244.6	1.4597	33.47	268
17	1.0350	.67	.53	.063	5.21	85.45	14.55	9.34	5.10	23.56	30.85	228.7	1.4595	33.80	210
24	1.0360	.70	.54	.060	4.86	85.07	14.93	10.07	4.76	21.31	32.19	224.1	1.4599	33.60	191
31	1.0345	.69	.53	.072	5.54	84.75	15.25	9.71	4.63	21.19	34.97	219.4	1.4604	33.33	291
Sept. 7	1.0370	.74	.58	.064	5.49	84.42	15.58	10.09	4.37	14.82	31.86	223.3	1.4569	33.97	222
14	1.0350	.78	.64	.060	5.74	83.70	16.30	10.56	4.30	6.10	41.83	217.0	1.4572	32.40	871
21	1.0350	.72	.61	.057	5.42	84.25	15.75	10.33	4.25	19.36	33.87	228.2	1.4564	34.75	314
28	1.0395	.77	.61	.078	5.14	83.74	16.26	11.12	4.90	23.02	36.65	221.1	1.4555	34.10	194
Oct. 5	1.0350	.74	.58	.049	5.60	......	......	......	4.40	8.45	41.56	211.7	1.4590	32.60	373
12	1.0335	.68	.55	.078	6.29	83.82	16.18	9.89	4.75	20.22	37.42	223.7	1.4579	33.55	720
19	1.0360	.86	.61	.062	5.81	82.66	17.34	11.53	5.81	10.70	37.64	217.1	1.4582	29.60	278
26	1.0370	.76	.57	.047	7.30	82.03	17.97	10.67	5.11	11.70	32.41	216.5	1.4575	37.35	386

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 205.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.	Relative size of globules.
1907.		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.*ct.	*P.ct.*	*P.ct.*					°*C.*	
July 27	1.0332	0.54	0.43	0.048	3.78	87.39	12.61	8.83	3.98	22.95	41.82	......	1.4595	36.53	369
Aug 3	1.0340	.51	.40	.039	3.19	87.92	12.08	8.89	4.49	27.86	30.81	241.4	1.4587	32.97	197
10	1.0340	.46	.38	.049	2.69	88.68	11.32	8.63	5.24	29.32	38.03	244.2	1.4605	32.17	152
17	1.0340	.46	.37	.029	3.30	89.05	10.95	7.65	5.03	26.52	37.83	241.1	1.4605	31.98	248
24	1.0340	.44	.35	.034	3.05	88.12	11.88	8.83	4.94	24.97	35.61	229.1	1.4574	32.50	130
31	1.0325	.43	.35	.028	3.14	88.20	11.80	8.66	4.81	......	......	......	....	......	176
Sept. 7	1.0330	.42	.35	.040	3.38	88.41	11.59	8.21	5.01	27.34	30.62	229.1	1.4603	33.45	131
14	1.0314	.44	.35	.026	3.00	88.97	11.03	8.03	5.15	25.73	37.40	229.8	1.4580	32.05	151
21	1.0320	.43	.35	.025	2.81	88.00	12.00	9.19	4.99	26.23	32.93	231.3	1.4549	33.25	204
28	1.0345	.45	.33	.033	3.01	88.33	11.67	8.66	4.99	25.29	31.65	230.8	1.4543	33.55	142
Oct. 5	1.0330	.46	.35	.042	3.17	88.34	11.66	8.49	4.55	28.05	32.20	230.6	1.4579	33.67	123
12	1.0315	.41	.33	.025	3.07	88.54	11.46	8.39	......	25.73	36.15	223.2	1.4565	33.10	124
19	1,0325	.44	.35	.030	3.10	88.05	11.95	8.85	5.20	24.45	33.08	234.1	1.4575	33.52	129
26	1,0330	.44	.36	.033	3.10	88.36	11.64	8.54	5.26	26.82	31.89	239.7	1.4562	33.05	183
Nov. 2	1.0335	.44	.35	.029	3.58	87.55	12.45	8.87	5.24	27.49	32.14	230.2	....	34.55	148
9	1.0314	.44	.36	.036	3.21	88.24	11.76	8.55	5.03	30.76	30.30	227.7	1.4577	33.90	127
16	1.0321	.45	.37	.031	3.33	87.80	12.20	8.87	4.95	29.71	30.97	235.1	1.4554	33.05	147
23	1.0312	.45	.37	.032	3.34	88.05	11.95	8.61	5.09	29.25	31.27	231.1	1.4576	33.27	128
30	1.0325	.45	.37	.036	3.32	88.04	11.96	8.64	5.73	27.92	31.54	229.6	1.4571	33.07	136
Dec. 7	1.0340	.45	.38	.037	3.17	87.66	12.34	9.17	5.91	24.38	33.29	227.3	1.4572	32.67	96
14	1.0337	.46	.38	.033	3.01	88.34	11.66	9.65	5.24	27.35	32.20	231.3	1.4568	32.88	81
21	1.0328	.44	.39	.032	3.30	88.30	11.70	8.40	5.18	26.39	32.77	228.8	1.4573	32.55	72
28	1.0330	.44	.36	.031	2.87	88.23	11.77	8.90	5.59	25.92	32.90	227.1	1.4571	32.98	87
1908.															
Jan. 4	1.0325	.45	.37	.033	3.06	88.04	11.96	8.90	5.48	28.01	32.68	227.4	1.4573	33.30	88
11	1.0330	.45	.37	.034	3.54	87.81	12.19	8.65	5.01	26.72	32.81	228.0	1.4557	32.75	116
18	1.0320	.45	.37	.043	3.21	88.24	11.76	8.55	5.57	28.22	32.73	226.6	1.4572	32.73	105
25	1.0320	.46	.37	.037	3.38	87.87	12.13	8.75	4.96	28.88	31.45	227.3	1.4554	33.80	120
Feb. 1	1.0340	.45	.38	.032	2.89	88.17	11.83	8.94	5.27	28.37	33.50	230.3	1.4571	32.25	87
8	1.0330	.44	.37	.037	3.26	88.01	11.99	8.73	4.73	27.01	32.07	229.1	1.4570	32.73	112
15	1.0327	.44	.37	.034	3.19	87.90	12.10	8.91	4.50	27.02	34.46	226.9	1.4564	33.00	106
22	1.0327	.44	.38	.034	3.38	87.75	12.25	8.87	5.04	28.63	33.81	226.7	1.4564	33.10	85
29	1.0346	.44	.37	.039	3.15	87.69	12.31	9.16	4.75	27.44	33.46	225.3	1.4564	33.10	82
Mar. 7	1.0336	.48	.37	.020	3.17	87.94	12.06	8.89	4.97	28.98	33.20	225.4	1.4582	32.75	126
14	1.0326	.48	.37	.020	3.19	88.06	11.94	8.75	......	27.95	......	225.3	....	33.55	82
21	1.0325	.45	.36	.019	3.28	87.96	12.04	8.76	5.32	27.78	32.84	225.3	....	......	87
28	1.0330	.49	.41	.047	2.94	88.26	11.74	8.80	5.00	26.71	36.16	224.1	....	33.48	97
Apr. 4	1.0325	.48	.40	.058	3.23	87.99	12.01	8.78	4.87	27.38	35.29	224.3	....	32.78	88
11	1.0322	.48	.39	.027	3.36	87.90	12.10	8.74	5.02	23.32	37.69	220.2	....	34.25	82
18	1.0317	.47	.38	.024	3.38	87.85	12.15	8.77	5.45	26.72	35.26	224.7	....	32.53	113
25	1.0325	.48	.40	.019	3.26	87.80	12.20	8.94	5.13	26.83	33.94	226.3	....	32.80	78
May 2	1.0330	.50	.41	.034	3.25	88.10	11.90	8.65	5.32	25.52	35.28	227.5	....	32.90	88
9	1.0330	.52	.43	.039	3.27	87.73	12.27	9.00	5.15	25.45	34.98	225.1	....	32.85	61
16	1.0337	.48	.41	.031	3.22	87.58	12.42	9.20	5.10	27.14	34.88	228.1	....	33.35	75
23	1.0320	.52	.45	.035	3.50	87.81	12.19	8.69	4.94	24.41	36.44	224.5	....	32.95	98
30	1.0335	.55	.42	.035	3.74	87.29	12.71	8.97	4.82	21.83	36.89	222.1	....	31.76	90
June 6	1.03 6	.54	.47	.031	3.20	87.30	12.70	9.50	5.65	19.14	38.71	219.0	....	32.35	79
13	1.0335	.53	......	.034	3.63	87.04	12.96	9.33	4.63	21.78	37.03	223.2	....	32.75	227
20	1.0334	.56	.46	.051	3.40	88.36	11.64	8.24	4.98	18.82	37.48	219.0	....	33.30	70
27	1.0326	.60	.48	.030	3.82	87.01	12.99	9.17	4.78	14.72	41.34	215.8	....	36.35	59
July 4	1.0330	.57	.52	.019	3.68	86.97	13.03	9.35	4.91	16.11	42.07	215.9	....	36.15	111
11	1.0338	.57	.47	.032	3.61	87.42	12.58	8.97	4.78	12.61	41.89	208.5	....	......	112
18	1.0330	.62	.55	.017	3.61	86.46	13.54	9.93	5.10	7.63	44.96	200.1	....	52.90	127
25	1.0330	.62	.56	.017	4.00	86.30	13.70	9.70	5.17	10.96	42.89	202.7	....	50.25	177
Aug. 1	1.0336	.63	.56	.033	3.52	86.51	13.49	9.97	5.04	9.76	41.61	210.7	....	47.43	175
8	1.0332	.71	.60	.030	3.53	86.92	13.08	9.55	4.22	10.09	42.22	204.3	....	47.33	185

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 206.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.	Relative size of globules.
1907.		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*					°*C.*	
June 8	1.0315	0.53	0.41	0.058	3.48	88.03	11.97	8.49	3.88	28.96	......	......	....	34.05	282
15	1.0290	.43	.34	.036	3.17	88.96	11.04	7.87	4.12	28.47	37.21	225.3	1.4604	32.63	256
22	1.0282	.40	.31	.038	2.58	90.05	9.95	7.37	......	32.47	29.80	234.8	1.4595	31.75	169
29	1.0290	.39	.30	.037	3.06	89.16	10.84	7.78	4.21	30.69	26.00	232.1	1.4591	33.38	304
July 6	1.0293	.37	.30	.029	3.00	......	......	......	4.61	33.38	29.02	229.3	1.4591	32.45	237
13	1.0290	.38	.29	.036	2.70	......	......	......	......	......	......	......	....	......	439
20	1.0295	.40	.31	.019	3.19	......	......	......	4.33	28.80	28.64	231.6	1.4595	34.10	276
27	1.0292	.37	.29	.029	2.63	89.90	10.10	7.47	4.54	26.27	34.06	223.9	1.4574	34.02	123
Aug. 3	1.0290	.37	.30	.025	2.76	89.96	10.04	7.28	4.70	26.38	38.76	243.5	1.4569	32.35	120
10	1.0290	.38	.30	.035	2.29	90.38	9.62	7.33	4.48	29.66	34.24	247.9	1.4598	31.38	126
17	1.0295	.37	.29	.026	2.70	88.98	11.02	8.32	4.31	28.31	35.11	246.7	1.4599	31.83	137
24	1.0300	.37	.28	.034	2.58	89.96	10.04	7.46	4.25	28.24	34.00	231.4	1.4570	32.20	114
31	1.0275	.38	.28	.022	2.94	89.77	10.23	7.29	4.00	24.70	34.02	229.5	1.4579	32.10	141
Sept. 7	1.0282	.38	.30	.028	2.76	90.01	9.99	7.23	4.06	22.91	27.60	235.4	1.4551	32.47	121
14	1.0275	.40	.32	.019	2.96	89.73	10.27	7.31	4.10	27.60	34.72	232.8	1.4543	31.35	140
21	1.0290	.40	.31	.018	2.71	89.43	10.57	7.86	4.30	23.09	30.47	236.9	1.4563	32.30	225
28	1.0300	.42	.30	.033	3.10	89.43	10.57	7.47	4.19	25.56	29.80	231.9	1.4574	31.80	174
Oct. 5	1.0300	.42	.31	.035	2.72	89.57	10.43	7.71	4.32	30.63	34.65	233.1	1.4555	31.82	139
12	1.0290	.39	.35	.020	2.94	89.33	10.67	7.73	4.23	30.23	32.58	231.9	1.4577	33.18	122
19	1.0290	.44	.32	.022	2.78	89.51	10.49	7.71	4.28	22.35	30.13	232.5	1.4555	33.07	99
26	1.0290	.42	.33	.033	3.06	89.60	10.40	7.34	3.66	......	......	......	....	......	147
Nov. 2	1.0300	.42	.32	.030	3.13	89.14	10.86	7.73	4.14	24.70	31.96	229.3	1.4551	33.05	196
9	1.0278	.43	.33	.034	3.01	89.20	10.80	7.79	4.13	22.34	31.84	232.2	1.4574	32.35	130
16	1.0286	.42	.34	.037	3.05	89.13	10.87	7.82	4.24	26.49	31.21	232.0	1.4576	32.00	147
23	1.0281	.41	.31	.066	3.05	89.18	10.82	7.77	4.20	26.84	32.46	232.6	1.4547	32.55	159
30	1.0290	.40	.31	.034	3.08	89.17	10.83	7.75	4.91	25.89	31.90	230.4	1.4572	32.40	120
Dec. 7	1.0290	.40	.30	.029	3.01	89.08	10.92	7.91	5.39	22.08	33.03	223.8	1.4575	33.40	138
14	1.0290	.42	.32	.031	2.39	89.56	10.44	8.05	4.45	22.29	35.16	231.9	1.4582	32.20	112
21	1.0295	.42	.33	.032	3.08	89.37	10.63	7.55	4.22	24.95	32.56	229.2	1.4574	32.92	103
28	1.0290	.40	.32	.030	2.86	89.29	10.71	7.85	4.79	21.46	33.54	225.3	1.4574	33.38	103
1908.															
Jan. 4	1.0290	.46	.34	.037	2.82	89.00	11.00	8.18	4.30	23.67	35.84	223.7	1.4586	33.55	125
11	1.0290	.45	.34	.046	3.23	89.15	10.85	7.62	3.69	23.49	35.06	224.0	1.4568	32.65	108
18	1.0295	.43	.33	.040	3.09	89.13	10.87	7.78	4.35	20.80	33.77	224.2	1.4579	33.05	122
25	1.0293	.44	.35	.036	3.13	88.95	11.05	7.92	3.58	24.01	34.76	226.1	1.4574	32.23	94
Feb. 1	1.0310	.45	.36	.030	2.70	89.07	10.93	8.23	4.19	25.41	34.03	222.6	1.4577	33.55	74
8	1.0310	.44	.38	.038	3.06	88.81	11.19	8.13	4.23	23.89	33.06	224.6	1.4563	32.40	93
15	1.0300	.45	.38	.034	2.93	88.72	11.28	8.35	3.50	23.08	34.99	222.5	1.4560	32.55	61
22	1.0310	.49	.41	.028	3.35	87.90	12.10	8.75	4.06	21.46	......	220.3	1.4588	31.95	95
29	1.0326	.53	.45	.048	3.03	87.82	12.18	9.15	4.09	......	......	218.2	1.4587	......	79
Mar. 7	1.0324	.56	.44	.045	3.03	87.97	12.03	9.00	4.09	17.73	35.55	218.5	1.4563	34.25	62
14	1.0338	.65	.52	.044	3.39	87.13	12.87	9.48	4.30	19.97	33.25	223.4	....	33.13	84
21	1.0343	.68	.54	.047	3.44	86.91	13.09	9.65	4.68	......	......	210.4	....	52.10	45
28	1.0353	.74	.63	.073	3.05	......	......	......	4.54	15.27	37.62	215.4	....	35.15	54
Apr. 4	1.0346	.77	.61	.095	3.73	86.05	13.95	10.22	4.48	......	38.72	......	....	34.80	132

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 209.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	S a p onification number.	Refractive index.	Melting point.	Relative size of globules.
1907.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*					° *C.*	
July 27	1.0310	0.61	0.46	0.065	3.95	87.16	12.84	8.89	3.89	21.47	43.11	220.6	1.4587	32.17	710
Aug. 3	1.0320	.49	.39	.045	3.14	88.77	11.23	8.09	5.20	24.23	42.24	239.0	1.4596	33.85	237
10	1.0320	.44	.34	.045	2.59	89.56	10.44	7.85	4.17	28.46	36.82	244.6	1.4605	32.23	163
17	1.0320	.45	.36	.049	2.80	89.55	10.45	7.65	4.35	28.45	35.65	244.4	1.4604	32.08	174
24	1.0320	.45	.34	.029	2.40	89.80	10.20	7.80	4.15	......	......	......	....	......	110
31	1.0300	.43	.32	.033	2.64	89.91	10.09	7.45	3.51	26.82	31.40	236.2	1.4602	31.72	128
Sept. 7	1.0300	.44	.33	.040	2.68	89.78	10.22	7.54	4.14	27.39	36.16	223.4	1.4601	32.70	158
14	1.0298	.46	.37	.025	2.67	89.59	10.41	7.74	4.21	26.32	32.39	232.3	1.4562	32.05	158
21	1.0290	.43	.33	.024	2.54	89.01	10.99	8.45	4.00	20.99	34.01	234.1	1.4564	33.40	179
28	1.0303	.46	.34	.042	2.72	89.79	10.21	7.49	......	24.30	32.54	231.2	1.4559	31.45	122
Oct. 5	1.0310	.47	.35	.037	2.96	89.37	10.63	7.67	4.31	29.19	32.13	230.5	1.4572	32.55	118
12	1.0295	.44	.35	.043	2.72	89.30	10.70	7.98	4.20	25.92	32.86	230.7	1.4565	30.82	123
19	1.0290	.49	.36	.040	3.92	......	......	......	4.10	26.29	33.51	232.8	1.4576	31.15	175
26	1.0305	.46	.37	.032	3.00	89.23	10.77	7.77	3.38	27.14	32.70	232.5	1.4577	31.10	132
Nov. 2	1.0315	.46	.37	.039	3.09	88.61	11.39	8.30	4.23	27.39	33.09	227.4	....	33.23	139
9	1.0285	.47	.35	.039	2.96	88.96	11.04	8.08	4.10	27.37	33.11	230.4	1.4565	31.87	104
16	1.0286	.44	.38	.039	3.00	89.19	10.81	7.81	3.64	28.03	32.48	232.2	1.4571	32.75	92
23	1.0298	.45	......	.031	3.14	88.82	11.18	8.04	4.33	25.71	32.22	231.1	1.4579	33.00	120
30	1.0295	.43	.33	.040	3.35	88.79	11.21	7.86	5.30	22.08	36.05	223.3	1.4582	34.07	120
Dec. 7	1.0310	.47	.35	.025	3.05	88.59	11.41	8.36	......	23.44	33.36	226.4	1.4570	32.35	85
14	1.0308	.47	.36	.043	2.54	89.19	10.81	8.27	4.93	23.75	34.74	232.0	1.4575	32.12	65
21	1.0310	.46	.39	.045	3.24	88.54	11.46	8.22	4.28	26.70	33.57	230.6	1.4573	31.60	114
28	1.0300	.45	.36	.033	2.73	89.07	10.93	8.20	4.50	......	......	......	....	......	88
1908.															
Jan. 4	1.0295	.46	.33	.046	2.74	89.38	10.62	7.88	3.74	23.58	36.42	224.4	1.4575	31.35	87
11	1.0305	.51	.37	.045	3.00	88.80	11.20	8.20	3.88	22.62	37.19	221.8	1.4582	33.15	99
18	1.0300	.50	.41	.040	2.95	89.03	10.97	8.02	4.49	22.31	36.97	225.7	1.4580	32.05	94
25	1.0300	.50	.38	.049	3.08	88.56	11.44	8.36	3.96	24.35	36.08	225.3	1.4576	32.00	123
Feb. 1	1.0314	.49	.41	.042	2.72	88.80	11.20	8.48	4.32	21.89	36.22	223.3	1.4558	32.00	74
8	1.0310	.48	.40	.056	3.15	88.66	11.34	8.19	4.20	23.99	34.44	221.7	1.4579	33.00	122
15	1.0298	.49	.39	.042	2.95	89.13	10.87	7.92	4.31	22.28	35.88	218.5	1.4565	32.75	72
22	1.0309	.52	.40	.043	3.08	88.61	11.39	8.31	4.06	24.15	36.44	222.8	1.4573	33.45	82
29	1.0307	.48	.40	.046	2.87	88.70	11.30	9.43	3.20	......	......	226.6	1.4563	31.93	119
Mar. 7	1.0315	.53	.40	.044	2.94	88.47	11.53	8.59	4.17	22.78	36.78	222.3	1.4579	31.48	86
14	1.0315	.50	.41	.033	3.06	88.43	11.57	8.51	4.19	25.53	......	224.5	....	33.35	180
21	1.0310	.52	.41	.038	3.18	88.41	11.59	8.41	4.64	24.10	37.80	221.4	....	33.20	74
28	1.0313	.54	.43	......	2.85	88.38	11.62	8.77	4.72	24.52	36.46	219.6	....	33.38	78
Apr. 4	1.0313	.58	.46	.059	3.69	87.51	12.49	8.80	4.37	20.31	37.80	218.0	....	34.85	81
11	1.0322	.61	.46	.061	3.75	87.32	12.68	8.93	4.60	17.67	42.47	212.9	....	34.80	73
18	1.0330	.60	.51	.053	3.32	87.39	12.61	9.29	4.99	20.90	41.09	221.6	....	32.60	75
25	1.0333	.59	.52	.053	3.33	87.47	12.53	9.20	4.53	21.78	34.94	224.2	....	33.03	85
May 2	1.0326	.57	.46	.044	3.29	87.72	12.28	8.99	4.84	22.84	35.19	223.3	....	33.20	66
9	1.0335	.62	.50	.079	3.27	87.24	12.76	9.49	4.82	22.31	33.05	222.0	....	32.40	69
16	1.0356	.65	.54	.055	3.52	86.80	13.20	9.68	4.97	21.36	38.34	221.5	....	33.20	50
23	1.0360	.75	.62	.074	3.74	86.30	13.70	9.96	4.53	18.78	34.82	221.0	....	33.80	65
30	1.0344	.73	.59	.082	3.75	86.30	13.70	9.95	3.57	22.28	36.63	221.4	....	34.40	98
June 6	1.0370	.76	.60	.083	3.76	86.02	13.98	10.22	4.34	20.80	35.51	223.2	....	34.85	63
13	1.0344	.72	.61	.084	4.05	86.44	13.56	9.51	4.33	20.60	36.88	219.0	....	35.13	77
20	1.0335	.72	.56	.086	4.05	87.21	12.79	8.74	4.35	19.12	37.74	217.5	....	37.40	65
27	1.0330	.70	.59	.100	6.54	84.39	15.61	9.07	4.08	21.34	38.99	214.8	....	36.98	122
July 4	1.0314	.72	.57	.033	4.01	86.57	13.43	9.42	4.52	20.93	39.06	215.8	....	37.80	114

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 300.

Week ending—		Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.	Relative size of globules.
1908.			*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*					°*C.*	
Jan.	4	1.0340	0.61	0.49	0.039	4.17	86.24	13.76	9.59	5.55	31.38	32.95	238.6	1.4567	37.88	283
	11	1.0330	.53	.44	.048	4.32	86.61	13.39	9.07	5.05	28.45	34.89	229.5	1.4575	33.58	220
	18	1.0330	.50	.43	.042	3.89	87.44	12.56	8.67	5.16	22.90	30.07	230.8	1.4565	32.95	173
	25	1.0315	.48	.40	.027	3.65	87.43	12.57	8.92	4.81	27.89	32.42	231.3	1.4570	......	265
Feb.	1	1.0330	.46	.40	.030	3.22	87.96	12.04	8.82	4.74	28.69	29.49	228.7	1.4544	33.30	175
	8	1.0320	.46	.38	.031	3.94	87.60	12.40	8.46	4.29	29.23	28.25	230.2	1.4563	32.88	177
	15	1.0330	.48	.41	.037	3.65	87.65	12.35	8.70	4.95	28.21	29.60	232.8	1.4549	33.58	150
	22	1.0320	.46	.40	.024	3.61	87.72	12.28	8.67	5.26	29.69	27.47	231.0	1.4558	33.80	148
	29	1.0325	.47	.40	.033	3.31	87.87	12.13	8.82	4.99	26.86	28.35	233.5	1.4557	33.50	199
Mar.	7	1.0329	.49	.40	.027	3.37	87.72	12.28	8.91	4.04	27.12	25.95	233.7	1.4563	33.55	124
	14	1.0330	.48	.40	.017	3.45	87.83	12.17	8.72	4.24	29.20	28.34	229.8	....	33.35	141
	21	1.0320	.49	.38	.031	3.38	88.02	11.98	8.60	5.28	27.84	28.12	232.0	....	33.40	128
	28	1.0314	.50	.41	.039	3.36	87.93	12.07	8.71	5.14	26.07	28.10	227.7	....	33.78	157
Apr.	4	1.0302	.46	.37	.038	3.50	88.11	11.89	8.39	4.42	24.12	35.72	223.3	....	34.00	131
	11	1.0312	.46	.36	.025	3.23	88.30	11.70	8.47	4.93	26.10	......	220.7	....	33.50	123
	18	1.0305	.47	.37	.018	3.35	88.43	11.57	8.22	5.00	26.76	......	227.5	....	32.88	128
	25	1.0304	.46	.37	.031	3.15	88.42	11.58	8.43	5.02	27.45	27.31	227.8	....	33.70	130
May	2	1.0313	.44	.38	.037	3.47	88.04	11.96	8.49	4.98	26.31	29.55	227.9	....	33.50	119
	9	1.0320	.47	.40	.036	3.30	88.30	11.70	8.40	4.90	27.18	27.53	229.3	....	33.78	106
	16	1.0316	.46	.40	.021	3.35	88.62	11.38	8.03	4.94	26.38	25.61	231.6	....	33.99	106
	23	1.0301	.45	.39	.026	3.44	88.74	11.26	7.82	4.65	......	......	......	....	......	146
	30	....	.48	.38	.042	3.40	88.62	11.38	7.98	......	25.73	28.60	231.1	....	33.88	169
June	6	1.0302	.46	.37	.024	2.98	88.60	11.40	8.42	4.45	25.80	29.86	229.9	....	34.18	115
	13	1.0302	.49	.40	.025	3.20	88.66	11.34	8.14	4.62	25.74	30.38	229.4	....	33.55	101
	20	1.0305	.47	.39	.041	3.30	......	......	......	4.75	23.54	31.88	227.6	....	34.00	83
	27	1.0296	.46	.38	.028	3.46	88.60	11.40	7.94	4.79	24.76	34.23	224.3	....	34.48	112
July	4	1.0304	.45	.39	.020	3.34	88.66	11.34	8.00	4.67	24.53	37.87	224.1	....	33.45	94
	11	1.0295	.45	.41	.028	3.11	88.61	11.39	8.28	5.05	25.43	37.21	222.0	....	33.40	83
	18	1.0300	.49	.42	.015	3.72	87.70	12.30	8.58	4.75	23.93	37.26	221.3	....	33.10	63
	25	1.0310	.47	.44	.019	3.59	87.87	12.13	8.54	5.22	23.11	39.37	222.0	....	33.90	83
Aug.	1	1.0310	.49	.44	.022	3.26	88.11	11.89	8.63	5.21	24.01	37.12	221.9	....	33.15	75
	8	1.0316	.51	.47	.021	3.55	87.74	12.26	8.71	5.13	24.44	35.54	222.9	....	33.05	98
	15	1.0313	.53	.49	.018	3.47	87.93	12.07	8.60	5.24	24.95	36.62	220.9	....	34.00	85
	22	1.0315	.58	.53	.017	3.61	87.47	12.53	8.92	5.12	23.90	34.91	223.7	....	32.88	58
	29	1.0320	.57	.52	.020	3.89	87.24	12.76	8.87	5.15	23.25	35.75	228.2	....	32.55	70
Sept.	5	1.0330	.58	.53	.012	3.99	87.11	12.89	8.90	5.00	20.26	33.65	222.9	....	33.75	88
	12	1.0315	.61	.55	.020	4.40	86.54	13.46	9.06	4.95	19.09	36.60	219.3	....	33.95	170
	19	1.0325	.64	.57	.036	4.58	86.17	13.83	9.25	4.93	17.37	36.99	215.5	....	34.90	144
	26	1.0334	.71	.61	.022	4.45	86.03	13.97	9.52	3.94	17.43	39.64	216.7	....	33.28	129
Oct.	3	1.0300	.72	.61	.049	4.65	85.86	14.14	9.49	3.74	......	......	......	....	......	71

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 301.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	Saponification number.	Refractive index.	Melting point.	Relative size of globules.
1907.		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*					*°C.*	
Oct. 5	1.0355	0.64	0.53	0.049	4.11	86.29	13.71	9.60	4.96	31.93	26.89	238.0	1.4555	31.70	227
12	1.0340	.57	.49	.050	3.89	86.66	13.34	9.45	5.35	32.03	30.22	235.7	1.4565	31.92	266
19	1.0340	.54	.46	.034	3.56	87.06	12.94	9.28	5.26	30.70	26.92	238.9	1.4568	32.70	204
26	1.0335	.50	.41	.038	3.90	87.20	12.80	8.90	5.11	27.70	30.30	235.1	1.4567	31.95	232
Nov. 2	1.0340	.49	.41	.035	3.98	86.98	13.02	9.04	4.77	27.11	27.87	235.5	1.4569	34.00	281
9	1.0317	.50	.39	.022	3.58	87.46	12.54	8.96	4.91	27.95	31.79	230.0	1.4574	32.80	151
16	1.0311	.50	.40	.034	3.69	87.63	12.37	8.68	4.75	28.11	29.90	232.3	1.4571	32.65	157
23	1.0338	.49	.39	.035	3.71	87.95	12.05	8.34	4.44	25.19	30.08	238.6	1.4552	33.40	165
30	1.0320	.48	.39	.032	3.75	87.64	12.36	8.61	5.77	25.79	31.31	232.6	1.4568	32.57	137
Dec. 7	1.0330	.49	.41	.047	3.83	87.39	12.61	8.78	5.67	25.88	31.46	229.6	1.4571	32.07	125
14	1.0325	.48	.39	.046	3.80	87.36	12.64	8.84	5.43	27.17	30.70	233.1	1.4572	33.08	164
21	1.0330	.47	.36	.041	3.85	87.34	12.66	8.81	......	27.48	28.77	232.8	1.4565	32.70	140
28	1.0320	.50	.42	.030	3.71	87.26	12.74	9.03	5.34	27.24	29.16	232.8	1.4559	32.40	152
1908.															
Jan. 4	1.0325	.50	.42	.034	3.75	87.33	12.67	8.92	5.05	24.75	30.35	228.7	1.4564	33.00	184
11	1.0320	.52	.43	.041	4.01	87.20	12.80	8.79	5.14	25.26	30.00	229.2	1.4562	32.90	171
18	1.0330	.53	.44	.035	3.75	87.67	12.33	8.58	5.11	23.28	29.87	230.8	1.4565	32.90	113
25	1.0325	.50	.43	.039	4.12	86.89	13.11	8.99	4.96	24.13	30.58	225.9	1.4568	33.60	146
Feb. 1	1.0326	.50	.42	.041	3.86	87.07	12.93	9.07	4.68	24.71	30.72	225.1	1.4568	34.85	148
8	1.0336	.52	.43	.046	4.24	86.69	13.31	9.07	4.44	25.89	31.19	230.4	1.4561	33.70	206
15	1.0324	.50	.42	.042	4.09	86.99	13.01	8.92	5.00	24.79	31.21	228.7	1.4553	33.23	161
22	1.0328	.52	.43	.044	4.00	87.26	12.74	8.74	......	27.04	30.39	229.0	1.4559	32.80	126
29	1.0336	.52	.43	.061	3.71	86.99	13.01	9.30	......	26.64	30.42	229.9	1.4561	33.48	345
Mar. 7	1.0329	.55	.42	.043	3.65	87.23	12.77	9.12	4.23	26.70	30.11	232.0	1.4575	32.75	122
14	1.0330	.52	.42	.036	3.76	87.10	12.90	9.14	3.67	26.76	......	227.9	....	32.90	118
21	1.0326	.50	.41	.034	4.07	87.10	12.90	8.93	5.83	25.35	32.99	218.1	....	33.95	116
28	1.0330	.53	.43	.040	3.77	87.50	12.50	8.73	5.27	26.15	29.73	227.4	....	33.90	224
Apr. 4	1.0321	.50	.41	.051	4.00	87.74	12.26	8.26	5.09	26.50	29.58	226.2	....	34.13	164
11	1.0320	.51	.41	.045	3.96	87.15	12.85	8.89	5.32	24.34	31.87	206.7	....	33.95	146
18	1.0312	.48	.42	.034	4.16	87.62	12.38	8.22	5.32	27.41	31.76	226.2	....	33.05	135
25	1.0314	.50	.41	.026	3.76	87.29	12.71	8.95	5.49	27.18	29.01	230.3	....	33.65	163
May 2	1.0327	.49	.42	.046	3.76	87.33	12.67	8.91	5.22	25.27	31.57	228.7	....	33.65	159
9	1.0325	.52	.43	.036	4.07	87.21	12.79	8.72	4.48	25.72	29.83	227.9	....	33.85	145
16	1.0329	.51	.42	.035	3.55	87.14	12.86	9.31	5.00	25.34	31.25	231.9	....	33.95	118
23	1.0315	.52	.44	.037	3.84	87.84	12.16	8.32	4.70	......	......	......	....	......	137
30	1.0313	.55	.47	.030	3.61	87.91	12.09	8.48	4.88	24.11	33.81	227.2	....	32.69	153
June 6	1.0325	.54	.45	.030	3.67	87.16	12.84	9.17	4.82	23.80	32.87	226.2	....	33.35	176
13	1.0312	.53	.45	.034	3.71	87.66	12.34	8.63	4.62	24.79	32.37	224.8	....	34.45	134
20	1.0305	.53	.41	.049	3.73	89.18	10.82	7.09	4.83	23.37	35.74	223.9	....	33.25	111
27	1.0308	.53	.42	.043	3.46	88.07	11.93	8.47	4.70	24.67	36.33	225.6	....	33.00	91
July 4	1.0316	.51	.44	.016	3.42	87.96	12.04	8.62	5.35	24.59	35.98	222.8	....	31.68	121
11	1.0303	.51	.42	.028	3.34	88.10	11.90	8.56	4.63	23.84	37.56	223.9	....	32.55	98
18	1.0298	.52	.47	.047	4.51	86.76	13.24	8.73	5.26	21.83	40.91	227.1	....	33.13	124
25	1.0273	.59	.52	.028	6.83	84.21	15.79	8.96	4.90	13.53	49.44	206.6	....	36.23	212
Aug. 1	1.0280	.49	.44	.029	4.99	86.75	13.25	8.26	4.77	13.14	48.51	207.3	....	35.50	151
8	1.0302	.54	.48	.031	3.96	87.29	12.71	8.75	4.94	18.46	44.01	215.9	....	32.75	86
15	1.0315	.57	.51	.028	4.01	86.90	13.10	9.09	5.02	23.55	40.16	217.9	....	34.15	103
22	1.0330	.55	.53	.017	3.87	86.93	13.07	9.20	5.04	19.06	38.28	217.4	....	32.80	87
29	1.0323	.61	.55	.021	3.99	86.73	13.27	9.28	5.16	25.79	36.04	223.5	....	......	95
Sept. 5	1.0340	.62	.57	.025	3.76	86.95	13.05	9.29	5.34	22.26	36.48	225.6	....	32.90	93
12	1.0333	.65	.55	.039	4.30	86.26	13.74	9.44	5.15	21.17	37.56	218.7	....	33.25	123
19	1.0375	.69	.60	.033	4.48	86.08	13.02	8.54	4.90	18.58	36.35	219.5	....	33.68	115

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 400.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	S a p onification number.	Refractive index.	Melting point.	Relative size of globules.
1907.		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*					*°C.*	
Oct. 12	1.0345	0.57	0.47	0.069	4.48	85.84	14.16	9.68	5.64	30.89	30.37	230.1	1.4563	34.07	390
19	1.0355	.54	.45	.056	4.07	86.17	13.83	9.76	5.15	29.43	28.40	233.1	....	34.70	307
26	1.0360	.53	.45	.047	3.88	86.49	13.51	9.63	5.30	31.84	31.63	233.5	1.4573	33.50	557
Nov. 2	1.0360	.53	.42	.046	4.03	86.65	13.35	9.32	5.50	30.91	......	232.3	....	33.35	513
9	1.0340	.51	.41	.053	4.33	86.42	13.58	9.25	4.28	31.57	31.12	236.2	1.4566	33.40	567
16	1.0313	.52	.43	.061	3.95	86.75	13.25	9.30	5.17	31.64	31.93	233.6	1.4566	32.45	485
23	1.0337	.52	.42	.050	3.92	87.02	12.98	9.06	5.06	27.75	30.80	230.6	1.4570	33.50	332
30	1.0336	.50	.39	.047	4.17	86.65	13.35	9.18	5.74	26.26	34.61	226.4	1.4576	32.62	987
Dec. 7	1.0330	.48	.39	.014	4.13	86.42	13.58	9.45	5.47	25.82	41.04	222.8	1.4583	30.75	340
14	1.0325	.47	.38	.041	4.31	86.77	13.23	8.92	5.56	27.68	37.32	227.3	1.4586	31.45	305
21	1.0335	.44	.37	.047	3.99	87.13	12.87	8.88	5.40	24.80	37.91	225.9	1.4585	32.88	306
28	1.0340	.45	.37	.030	3.54	87.48	12.52	8.98	5.34	25.49	39.94	220.9	1.4569	31.35	318
1908.															
Jan. 4	1.0320	.45	.36	.039	3.30	87.95	12.05	8.75	5.01	25.41	29.97	236.8	1.4558	32.90	234
11	1.0330	.47	.38	.045	3.99	87.19	12.81	8.82	5.44	27.41	32.43	230.6	1.4562	33.65	283
18	1.0340	.49	.39	.039	3.57	87.89	12.11	8.54	5.04	23.68	31.65	227.6	1.4572	33.20	190
25	1.0328	.51	.40	.048	3.73	87.04	12.96	9.23	5.01	27.44	31.39	225.1	1.4558	32.83	274
Feb. 1	1.0331	.51	.42	.044	3.53	87.09	12.91	9.38	4.93	28.29	31.23	228.2	1.4552	32.85	232
8	1.0351	.52	.44	.062	3.92	86.72	13.28	9.36	4.74	29.07	31.89	228.8	1.4565	32.83	331
15	1.0340	.53	.44	.055	3.78	87.06	12.94	9.16	4.75	28.38	31.69	232.3	1.4555	32.75	240
22	1.0350	.56	.45	.020	3.55	86.89	13.11	9.56	5.04	28.56	31.83	228.3	1.4557	33.60	195
29	1.0346	.53	.45	.058	3.62	86.83	13.17	9.55	5.39	......	......	231.6	1.4561	......	330
Mar. 7	1.0334	.54	.43	.046	3.72	86.99	13.01	9.29	4.39	26.69	32.74	226.9	1.4575	33.75	173
14	1.0337	.55	.44	.030	3.61	86.99	13.01	9.40	4.58	26.12	34.70	224.1	....	34.20	450
21	1.0343	.55	.44	.038	3.79	87.00	13.00	9.21	5.45	26.80	32.50	226.0	....	33.68	156
28	1.0350	.55	.47	.057	3.52	87.31	12.69	9.17	5.28	24.92	34.05	226.5	....	34.00	269
Apr. 4	1.0340	.55	.45	.064	4.07	87.01	12.99	8.92	4.75	26.09	33.43	222.5	....	33.80	217
11	1.0340	.58	.43	.063	3.85	86.82	13.18	9.33	4.87	23.40	37.30	223.0	....	33.60	236
18	1.0332	.55	.44	.042	3.95	87.03	12.97	9.02	5.30	24.37	38.04	223.6	....	33.10	202
25	1.0337	.56	.45	.037	3.53	87.12	12.88	9.35	5.44	25.41	33.11	225.1	....	33.55	162
May 2	1.0344	.55	.45	.052	3.90	86.74	13.26	9.36	5.14	29.83	33.92	225.0	....	34.10	236
9	1.0346	.56	.47	.050	3.96	86.66	13.34	9.38	5.09	24.13	33.30	227.5	....	34.38	186
16	1.0347	.55	.48	.045	3.53	87.15	12.85	9.32	5.10	24.59	32.66	228.2	....	34.48	202
23	1.0326	.55	.43	.048	3.43	87.60	12.40	8.97	4.68	23.17	34.64	225.5	....	33.50	225
30	1.0320	.59	.46	.045	3.91	86.97	13.03	9.12	4.55	25.12	33.46	226.3	....	33.90	203
June 6	1.0340	.60	.46	.044	4.52	86.52	13.48	8.96	4.54	24.81	33.17	225.1	....	34.05	281
13	1.0328	.59	.46	.046	4.35	86.80	13.20	8.85	4.82	24.73	35.84	222.5	....	35.38	146
20	1.0310	.59	.46	.051	3.87	88.31	11.69	7.82	4.46	23.33	36.28	220.3	....	35.85	171
27	1.0300	.60	.48	.049	4.78	87.32	12.68	7.90	3.80	22.69	35.64	224.0	....	36.65	209
July 4	1.0307	.61	.50	.028	4.06	87.35	12.65	8.59	4.24	23.01	37.86	218.2	....	36.55	179
11	1.0300	.58	.49	.022	3.91	87.30	12.70	8.79	4.39	21.24	37.86	219.6	....	36.55	158
18	1.0290	.61	.55	.028	4.28	87.05	12.95	8.67	3.90	22.00	38.27	216.1	....	37.00	194
25	1.0300	.59	.51	.031	4.03	87.21	12.79	8.76	4.56	22.35	38.44	217.9	....	35.88	194
Aug. 1	1.0303	.58	.54	.021	4.20	87.21	12.79	8.59	4.29	22.41	38.77	216.5	....	36.60	194

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 402.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	S a p onification number.	Refractive index.	Melting point.	Relative size of globules.
1907.		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*					°*C.*	
Oct. 26	1.0360	0.58	0.48	0.054	4.49	85.94	14.06	9.57	5.08	31.42	35.18	232.3	1.4573	32.87	536
Nov. 2	1.0350	.51	.43	.051	5.14	85.68	14.32	9.18	4.60	28.89	30.73	233.1	....	33.30	686
9	1.0329	.51	.12	.051	4.48	86.38	13.62	9.14	4.73	30.89	29.36	235.2	1.4559	32.27	521
16	1.0326	.52	.42	.047	4.08	87.06	12.94	8.86	4.68	31.69	27.77	236.4	1.4574	32.32	519
23	1.0328	.50	.42	.045	4.31	86.82	13.18	8.87	4.56	26.81	28.56	236.2	1.4566	33.55	524
30	1.0330	.52	.43	.049	4.20	86.66	13.34	9.14	5.45	27.00	27.57	236.2	1.4563	32.25	944
Dec. 7	1.0345	.53	.44	.060	4.20	86.59	13.41	9.21	5.85	25.68	30.72	230.9	1.4570	32.80	405
14	1.0040	.52	.42	.041	3.96	86.77	13.23	9.27	5.40	29.05	30.00	232.2	1.4566	32.55	371
21	1.0340	.51	.42	.048	4.21	86.54	13.46	9.25	4.86	27.58	29.34	233.7	1.4563	33.95	424
28	1.0335	.49	.41	.041	3.92	87.09	12.91	8.99	5.18	27.22	30.15	232.8	1.4564	32.73	460
1908.															
Jan. 4	1.0325	.53	.42	.048	3.77	87.17	12.83	9.06	5.09	26.83	34.47	222.3	1.4560	32.85	339
11	1.0340	.52	.42	.049	3.99	86.93	13.07	9.08	5.24	15.12	30.64	230.5	1.4554	33.25	354
18	1.0337	.54	.43	.042	3.61	87.22	12.78	9.17	4.89	27.29	29.49	228.9	1.4555	33.27	312
25	1.0340	.53	.44	.043	4.03	86.59	13.41	9.38	4.94	25.19	29.40	230.1	1.4558	32.95	275
Feb. 1	1.0344	.53	.43	.043	3.69	86.99	13.01	9.32	4.89	25.44	30.70	204.4	1.4569	32.75	272
8	1.0340	.56	.45	.056	3.86	86.94	13.06	9.20	4.14	24.47	32.08	228.5	1.4558	33.40	235
15	1.0330	.53	.44	.056	3.92	86.94	13.06	9.14	5.00	......	32.37	227.3	......	33.00	318
22	1.0340	.56	.46	.051	3.84	86.74	13.26	9.42	4.75	26.10	31.61	228.9	1.4562	32.80	277
29	1.0344	.54	.46	.041	3.80	86.79	13.21	9.41	4.05	26.85	31.67	228.9	1.4566	......	264
Mar. 7	1.0334	.55	.44	.030	3.80	86.89	13.11	9.31	4.40	25.25	32.68	228.1	1.4576	33.05	262
14	1.0337	.56	.44	.041	3.79	86.85	13.15	9.36	5.33	24.29	35.25	222.8	....	33.80	253
21	1.0340	.55	.44	.036	3.93	87.06	12.94	9.01	5.12	25.58	......	223.6	....	34.18	173
28	1.0344	.55	.45	.060	3.78	87.14	12.86	9.08	5.13	23.53	35.39	225.2	....	33.73	317
Apr. 4	1.0336	.55	.44	.044	4.16	87.06	12.94	8.78	4.77	23.08	34.83	225.7	....	34.25	184
11	1.0327	.54	.46	.047	3.94	86.90	13.10	9.16	5.35	22.37	38.15	221.0	....	34.18	277
18	1.0327	.54	.44	.034	4.12	87.31	12.69	8.57	5.29	22.99	34.67	224.1	....	33.45	325
25	1.0334	.56	.44	.047	3.76	86.98	13.02	9.26	5.20	25.79	33.18	225.4	....	33.90	279
May 2	1.0345	.55	.46	.041	4.09	86.74	13.26	9.17	5.33	23.84	34.53	224.4	....	33.50	204
9	1.0340	.56	.45	.036	4.20	86.54	13.46	9.26	4.85	23.54	33.75	225.3	....	33.75	210
16	1.0340	.55	.45	.044	3.78	87.32	12.68	8.90	......	22.38	35.63	221.8	....	34.80	175
23	1.0325	.55	.46	.042	3.79	87.25	12.75	8.96	4.60	23.15	35.51	223.3	....	33.45	193
30	....	.61	.44	.047	3.82	87.16	12.84	9.02	......	22.65	37.00	220.2	....	33.15	278
June 6	1.0330	.61	.49	.048	4.51	86.70	13.30	8.79	4.72	21.85	37.11	221.2	....	34.45	267
13	1.0330	.58	.49	.053	4.55	86.28	13.72	9.17	4.78	18.42	41.33	214.4	....	34.50	185
20	1.0330	.64	.53	.062	4.71	86.36	13.64	8.93	4.64	15.38	43.59	213.8	....	34.50	184
27	1.0336	.70	.60	.057	4.92	85.44	14.56	9.64	4.31	17.92	42.02	213.8	....	35.15	215
July 4	1.0340	.69	.41	.025	4.75	85.63	14.37	9.62	4.29	17.22	42.98	211.7	....	35.48	227
11	1.0325	.69	.61	.019	4.01	86.27	13.73	9.72	4.49	17.64	42.25	212.4	....	36.40	142
18	1.0314	.71	.65	.044	4.50	86.27	13.73	9.23	4.14	14.98	41.33	210.4	....	37.05	210

TABLE I.—*Analysis of the milk of each cow, by 7-day periods*—Continued.

COW NO. 403.

Week ending—	Specific gravity of milk.	Total nitrogen.	Casein nitrogen.	Albumin nitrogen.	Fat.	Water.	Total solids.	Solids not fat.	Sugar.	Reichert-Meissl number.	Iodin number.	S a p onification number.	Refractive index.	Melting point.	Relative size of globules.
1908.		*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*					°*C.*	
Feb. 22	1.0358	0.57	0.46	0.072	4.06	86.37	13.63	9.57	4.84	31.84	36.04	227.6	1.4564	32.80	415
29	1.0360	.51	.43	.046	3.53	87.15	12.85	9.32	5.21	29.22	33.37	229.6	....	32.80	189
Mar. 7	1.0338	.51	.39	.058	3.45	87.58	12.42	8.97	5.27	27.49	29.79	252.3	1.4573	31.85	502
14	1.0334	.50	.38	.036	3.27	87.51	12.49	9.22	5.52	28.87	34.13	227.6	....	33.35	323
21	1.0333	.51	.37	.034	3.35	87.79	12.21	8.86	5.78	27.11	32.77	227.1	....	32.88	217
28	1.0327	.48	.37	.063	3.35	87.93	12.07	8.72	5.28	28.52	33.01	229.5	....	33.25	352
Apr. 4	1.0333	.49	.39	.059	3.45	87.88	12.12	8.67	4.98	26.78	34.56	225.6	....	33.65	285
11	1.0320	.46	.38	.047	3.36	87.78	12.22	8.86	4.83	24.26	40.36	219.3	....	33.50	359
18	1.0320	.48	.36	.053	3.33	88.39	11.61	8.28	5.63	25.99	35.80	226.2	....	31.45	226
25	1.0323	.46	.35	.029	2.96	88.14	11.86	8.90	5.33	27.47	31.47	230.4	....	32.68	188
May 2	1.0329	.46	.35	.040	3.16	88.47	11.53	8.37	5.58	26.10	32.31	227.1	....	33.00	229
9	1.0336	.46	.38	.048	3.26	88.00	12.00	8.74	5.00	25.69	33.16	228.6	....	33.68	208
16	1.0323	.47	.36	.045	3.01	88.68	11.32	8.31	5.29	26.54	32.90	232.8	....	32.90	147
23	1.0316	.47	.37	.051	3.19	88.60	11.40	8.21	4.65	25.51	34.09	228.0	....	32.20	204
30	1.0307	.47	.38	.035	3.00	88.48	11.52	8.52	4.93	25.72	33.45	230.0	....	32.30	186
June 6	1.0320	.48	.37	.043	3.45	87.99	12.01	8.56	5.12	27.43	34.54	228.6	....	33.00	194
13	1.0310	.50	.37	.036	3.30	88.19	11.81	8.51	4.63	26.21	34.90	227.1	....	32.90	130
20	1.0310	.49	.38	.042	3.16	88.44	11.56	8.40	4.70	24.43	35.20	225.9	....	32.90	120
27	1.0323	.49	.31	.067	3.19	88.59	11.41	8.22	4.26	26.57	35.84	226.9	....	33.25	161
July 4	1.0315	.49	.41	.035	2.92	88.53	11.47	8.55	4.73	25.55	35.16	225.6	....	33.55	125
11	1.0316	.50	.42	.019	3.07	88.25	11.75	8.68	5.03	......	......	......	....	33.13	117
18	1.0310	.50	.44	.035	3.25	88.35	11.65	8.40	5.13	24.10	36.59	224.0	....	33.30	147
25	1.0310	.51	.44	.036	3.19	88.41	11.59	8.40	5.11	26.64	35.80	239.7	....	33.20	129
Aug. 1	1.0315	.51	.43	.040	2.99	88.41	11.59	8.60	5.36	27.33	34.31	226.6	....	32.30	169
8	1.0320	.53	.46	.032	2.57	88.60	11.40	8.83	5.13	25.12	35.72	224.0	....	32.70	120
15	1.0318	.53	.46	.033	3.01	88.24	11.76	8.75	4.53	26.44	33.99	225.4	....	33.20	127
22	1.0320	.53	.45	.026	4.02	84.23	15.77	11.75	5.08	27.19	34.66	225.1	....	32.20	205
29	1.0326	.53	.46	.028	3.33	87.85	12.15	8.82	5.16	26.75	35.45	223.7	....	32.05	133
Sept. 5	1.0320	.55	.46	.085	3.30	87.82	12.18	8.88	5.33	25.32	35.36	225.5	....	32.55	143
12	1.0322	.56	.46	.053	3.61	87.39	12.61	9.00	5.20	25.46	35.72	227.1	....	32.33	142
19	1.0357	.56	.45	.054	3.46	87.71	12.29	8.83	5.18	23.58	37.16	224.2	....	32.55	129
26	1.0333	.60	.50	.038	3.83	86.99	13.01	9.18	4.72	23.76	37.13	223.5	....	33.15	172
Oct. 3	1.0343	.61	.48	.070	3.80	87.01	12.99	9.19	4.54	......	......	......	....	32.68	167
10	1.0333	.60	.51	.052	3.75	87.18	12.82	9.07	4.85	......	......	......	....	......	179
17	1.0325	.49	.39	.050	3.88	89.12	10.88	7.00	2.85	......	......	......	....	......	250
24	1.0333	.61	.44	.095	3.98	87.16	12.84	8.86	......	23.27	37.32	223.8	....	33.60	214
31	1.0333	.58	.46	.105	4.26	86.78	13.22	8.96	3.88	23.59	35.42	224.9	....	33.70	190
Nov. 7	1.0290	.61	.45	.088	3.87	87.49	12.51	8.64	......	24.07	35.06	228.2	....	32.85	....
14	1.0331	.61	.45	.098	3.92	87.08	12.92	9.00	4.23	24.43	35.54	225.2	....	33.35	142
21	1.0330	.60	.44	.081	3.95	87.06	12.94	8.99	4.40	24.89	34.94	227.3	....	33.20	193
28	1.0325	.61	.46	.110	3.94	87.17	12.83	8.89	4.34	25.65	35.33	229.0	....	32.65	160
Dec. 5	1.0329	.64	.47	.087	4.21	86.50	13.50	9.29	4.55	25.20	35.93	224.6	....	32.95	98
12	....	.65	.48	.081	3.93	86.87	13.13	9.20	4.59	25.36	34.03	226.5	....	32.65	146
19	....	.64	.49	.091	4.10	86.69	13.31	9.21	4.40	25.84	34.88	226.2	....	33.05	106
26	....	.....	......	......	......	......	......	......	......	23.03	35.88	224.9	....	33.30	....

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